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ERRATA.

P. 31, line 8 from bottom, for IPOMEÆ read IPOMŒÆ.

P. 48 and 49, transpose figs. 3 and 4.

P. 66, footnote 14, for 1897 read 1896.

P. 117, last footnote, for [3] read [4].

P. 126, line 1, for *merican* read *American*.

P. 133, line 11, for algæ read algal.

P. 138, line 5, for Stichoglœoa read Stichoglœa.

P. 141, line 26, for Wood read Woods.

P. 191, line 4, for certaiu read certain.

P. 227, line 10 from bottom, for ciliferous read ciliiferous.

P. 275, line 22, for Wahtenberg read Wahlenberg.

P. 290, line 14 from bottom, for *3l* read *3e*.

P. 301, line 6, for remain ingin read remaining in.

P. 388, line 9, for Sc. B. read Sc. D.

P. 442, line 8 from bottom, *dele* comma after Stanley.

P. 443, line 10, for specimens read species.

P. 444, line 18, for *longifolio* read *longifolia*.

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VOLUME XXIV NUMBER 1

BOTANICAL GAZETTE

JULY 1897

CONTRIBUTIONS FROM THE CRYPTOGAMIC LABORATORY OF HARVARD UNIVERSITY. XL.

NEW OR PECULIAR ZYGOMYCETES. 2. SYNCEPHALASTRUM AND SYNCEPHALIS.

ROLAND THAXTER.

(WITH PLATES I AND II)

ALTHOUGH the Mucorineæ, from their great variety and from the ease with which they may be cultivated, offer an attractive field for investigation, they appear to have received but scant attention in this country, if one may judge from the infrequent references to them that are found in our literature, and their meager representation in "Floras" in which they are listed. It must be well known, however, to anyone who has used them for teaching purposes that they are among the most varied and abundant of our moulds. The somewhat limited experience of the writer would indicate that our Mucor flora is a very rich one, since all the described genera, with two or three exceptions, appear to be for the most part well represented in it; and thanks to the admirable papers of A. Fischer and others, but primarily to those of Van Tieghem, whose writings may well serve as models for such work, their systematic study presents comparatively few difficulties except in so far as concerns the more obscure species of the genus Mucor.

The American species included in the group of so-called Cephalideæ seem to be even less well known than those of the

mucors proper, and although Professor Farlow has mentioned the occurrence of two species,[1] *Syncephalis sphaerica* and *Piptocephalis Freseniana*, in Massachusetts, with the exception of the present writer's note on Dispira in a former number of the GAZETTE there appears to have been no further mention of the occurrence of any American member of the group; although it comprises many of the more striking fungi that are found in laboratory cultures.

Among the species of Syncephalis which have come under the writer's notice there are several that seem to be distinct from any of the forms previously described, and are of interest not only from the fact that they serve further to illustrate the specific peculiarities of a genus distinguished for its remarkable types, but also for the reason that in two of the forms enumerated the process of spore-formation can be followed with greater accuracy than is possible in any of the commoner species known to the writer. In the same connection a brief account may be given of the sporulation of Syncephalastrum, a genus the characteristics of which appear to be but little known, and prove to possess considerable interest.

It is well known that authorities are by no means agreed as to the homologies of the non-sexual reproductive organs of the Cephalideæ; what we may call for convenience the French school following the opinion of Van Tieghem in considering the "spore-rows" of this group as the homologues of the sporangia in typical mucors, from which they are held to differ merely by reason of the fact that they are cylindrical instead of spherical in shape, and contain a single row of superposed spores endogenously produced instead of a more or less indefinite rounded mass. The walls of these spores having been formed in close union with those of the sporangium, the latter appears finally to break up into a row of spores that present the appearance of having been exogenous in origin. Within the past year the conclusions of Van Tieghem have been further substantiated through the researches of M. Léger, who states that his studies confirm

[1] Bull. Bussey Instit. 2: 224, 1878; *l. c.* 1: 431. 1871.

this "sporangial" theory in all respects in so far as concerns the genera Syncephalis and Piptocephalis. The cylindrical sporangia in these cases are said by him to be filled with protoplasm containing many nuclei which becomes simultaneously divided into as many portions as there are spores in each spore row; these masses being separated by an intersporal zone of hyaline protoplasm, as in the sporangia of typical mucors.

Other authors, again, are not inclined to accept this homology, and A. Fischer, for example, in his well-known revision of the Phycomycetes in Rabenhorst's *Kryptogamenflora*, inclines to the opinion that, in the absence of any connecting form between these two supposed types of sporangia, it is as reasonable as well as more simple to assume that these so-called conidia have had an exogenous origin independent of that which has given rise to sporangia of the normal type, and are therefore not homologous. Having been personally inclined to agree with the views expressed by Professor Fischer in this connection, the writer was somewhat surprised to find, in examining the spore rows of a species of Syncephalastrum that has been kept in cultivation for several years in the laboratory, a condition of things which, in so far as this genus is concerned, not only confirms the theories of Van Tieghem just mentioned, but affords at least an approach to the very connecting link between the spherical and the cylindrical form, the absence of which was pointed out by Fischer.

The species of Syncephalastrum, three of which have been described, appear to be in general of tropical origin, since in all cases in which they have been observed, with perhaps one exception, the material on which they have been cultivated has been brought from the warmer regions of the earth. In the writer's laboratory substances from Africa, China, Ceylon, and Java have repeatedly yielded the same species, which, although very variable in cultivation in regard to its branching and to the number of spores in each spore-row, cannot be separated from *S. racemosum* Cohn. It grows and fruits luxuriantly on agar, and is sharply distinguished from other members of the Cephal-

ideæ in that its fertile and vegetative hyphæ are uniform, as well as from the fact that it is never even partially parasitic in its habit. The undifferentiated fertile branches end in a spherical head, from which, as in some species of Syncephalis, the spore-rows radiate in all directions, forming an Aspergillus-like fructification. The spore-rows arise as cylindrical cells, formed by budding directly from this head, which normally contain at maturity a single row of superposed spores (*fig. 3*) resulting from the separation of the protoplasmic contents of each cell into a number of distinct portions corresponding to that of the mature spores. As far as has been seen, this separation appears to occur simultaneously, and not by gradual constriction, the successive masses becoming separated by a hyaline intersporal substance exactly similar in appearance to that which occurs in ordinary sporangia (*fig. 1*). After this separation has been effected, each mass surrounds itself with a wall visibly distinct from that of the cylindrical mother-cell (*figs. 2–3*), within which the spores thus formed are practically free. That this is the case is readily demonstrated by crushing the spore-rows under a cover glass, and in such preparations abundant instances may be observed in which the spores have been forced out of the sporangia, as the cylindrical mother cells must undoubtedly be called, which may thus be left wholly empty or but partly filled with spores that may lie more or less irregularly in its interior (*figs. 2* and *4*). By selecting a head not fully mature it is often possible by careful crushing to force all the spores out of the sporangia through their ruptured tips, leaving them empty but still intact and adherent to the fertile head. In nature the spores are freed by the eventual disappearance of the sporangium wall, which shrivels and breaks up without undergoing the deliquescence characteristic of all other Cephalideæ at this stage; so that the spores are dispersed in a dry condition instead of cohering in a viscous drop. The sporangial nature of the spore-rows is further shown by the fact that it is by no means unusual to find instances in which the spores are formed not in single rows, as in *fig. 3*, but more irregularly through the occur-

rence of longitudinal or oblique planes of separation, as in *figs. 1* and *2*. In such cases the sporangium is more or less distinctly swollen terminally, as in *fig. 2*, and presents a condition which may well be regarded as intermediate between an ordinary sporangium and the more typical uniseriate type represented in *fig. 3*.

Although the species of Syncephalastrum are not, as has been mentioned above, in any degree parasitic, and although there are certain important structural differences which distinguish them from other Cephalideæ, their close relationship to the latter can hardly be doubted. It would therefore seem quite safe to assume that the corresponding spore-rows in Syncephalis would prove to have an exactly similar mode of development. An examination of two undescribed species of this genus, however, shows conclusively that the processes in the two cases are by no means identical, and that in this instance we have a far more definite approach to the ordinary exogenous type of spore formation than is found in Syncephalastrum.

The species of Syncephalis appear to vary very greatly in so far as concerns the ease with which the changes connected with spore formation may be observed, and the distinctness with which it may be followed depends, not on the size of the spores themselves, but on the width of the interval which separates successive spores in given species. In the few common forms which the writer has recently had an opportunity of examining in a fresh condition, in connection with the preparation of the present note, namely *S. cordata*, *S. depressa*, *S. cornu*, and *S. nodosa*, phenomena, which in the two species just mentioned are readily seen, can be made out only with great difficulty. The form in which the true condition of things is most strikingly shown is an undescribed species from Liberia, which, though so closely allied to *S. cordata* that it was at first mistaken for that species, presents well-marked specific differences. This species, a description of which is reserved for a subsequent paper, is characterized by producing rather small oblong spores in somewhat elongate spore-rows, the former during their formation being sep-

arated by so wide an interval that the various accompanying changes may be readily seen even without the use of high magnifications. The successive steps in this process may be summarized as follows: Beginning with the immature "sporangial filament," if we may use this term to indicate the structures from which or within which the spores are eventually produced, we find them filled as usual with undifferentiated granular protoplasm. The first indication of spore-formation is seen in the appearance of successive indentations of the protoplasm which correspond to the future lines of separation between the successive spores. These indentations extending completely around the sporangial filament thus divide it by a series of successive rings into a number of segments corresponding to the number of spores to be produced. As this indentation gradually increases the protoplasmic mass within the sporangial filament becomes correspondingly constricted, and by treating the specimen with eosin or other stains the indented area may be seen to be made up of two parts (*figs. 39–41*), the one hyaline (*a*) unable to absorb stain and resembling in appearance the intersporal substance of ordinary sporangia, the other (*b*) acting toward stains like granular protoplasm. As the development proceeds the indentation just described and the corresponding constriction of the protoplasmic contents become more and more pronounced, while at the same time the stainable portion (*fig. 40 b*) of what may conveniently be called the "intermediary zone" increases in volume. At this stage the protoplasmic contents of the sporangial filament has become separated into distinctly formed oblong portions connected by gradually narrowing protoplasmic isthmuses (*fig. 41*). These oblong portions become eventually completely separated and are surrounded by a distinct wall which, however, on either side is hardly distinguishable from the wall of the sporangial filament (*fig. 42*). In this mature condition the intermediary zones may be seen as distinct rings (indicated by dotted lines in *fig. 42*), often distinctly elevated above the adjacent surface of the spores, probably by reason of the fact that they begin to become deliquescent almost as soon as the spore wall

is formed. While these changes are taking place the tip of the sporangial hypha undergoes a somewhat similar modification. A cap appears within it (*fig. 39*) which is at first composed of non-stainable material like that of the intermediary zones, but which, like the latter, soon shows a distinction between a stainable and non-stainable portion (*fig. 40*). This terminal cap eventually shares a fate similar to that of the intermediary zones, becoming deliquescent and leaving the terminal spore of the row evenly oblong like the rest.

Having had abundant material of this species growing in a fresh condition it was possible to verify many times the course of development just described, the correctness of which was further substantiated by the examination of a second species subsequently described as *S. pycnosperma.* The sporangial hyphæ of this species are far larger than those of the form last described, although the intermediary zones are relatively narrower. The process by which the latter arise is exactly similar to that of the African form, except that the stainable portion of the zone is proportionately less well developed, forming finally a thin "separation disk" (*fig. 36 b*) which, as the spore matures, loses its power of absorbing stain and is converted into a refractive oily substance. That portion of the zone, moreover, which was at the outset unstainable persists as the spore matures, being converted into a thick wall firmly united to that of the spore and barely distinguishable from it (*fig. 38 a*, in which this distinction is much exaggerated), and it is the persistence of this area (*a*) which gives to the ripe spores their peculiar form (*figs. 34, 37, 38*). The same differences may be noted in the phenomena which occur at the apex of the sporangial filaments, the process being even more clearly marked than in the species last described. The portion of the filament separated above the terminal spore is here so large that it has the appearance of a definite small cell; and as the spore matures it passes through the same changes which have just been described as characteristic of the separation zones. The portion which is at first stainable becomes converted into oily material, and disappears together with the portion of the wall of

the sporangial filament that immediately surrounds it; while the non-stainable part, as in the case of the zones, is transformed into a permanent wall. The terminal spore thus ends in a cup-like depression (*fig. 38*, lower end), by which it is at once distinguished from the two other spores which compose the spore-chain at maturity.

It is thus apparent, in these two instances at least, that the process of spore formation is distinctly different from that which has been described in Syncephalastrum, from the fact that the contents of the sporangial filament is converted into spores, not through its simultaneous separation into successive masses, but as the result of a more or less gradual intrusion of "intermediary zones" which develop from the periphery inward till the protoplasmic content is cut into segments. In the species last described it is evident that the intermediary zones consist of two parts; one of which is, or at least becomes, a permanent structure which, though formed earlier than and independently of the spore wall proper, is ultimately closely united with it; while the other constitutes an intermediate portion ultimately converted into an oily substance, although at first it seems to be protoplasmic, and corresponding to the plane of separation between adjacent spores, their function in this process being evident.

A similar series of changes may be made out with sufficient distinctness in *S. Wynneæ* described below; but although in some of the common species, like *S. nodosa* and *S. cordata*, it is possible to observe the progressive constriction of the contents of the sporangial filament into portions corresponding to the spores, the extreme narrowness of the intermediary zones in these species renders it almost impossible to follow out the process in detail, yet it may be fairly assumed that these details are not essentially different from those above described.

In the species subsequently described as *S. tenuis* a somewhat scanty supply of mounted material only has been available for study in this connection, so that it has been impossible to determine the character of its intermediary zones. It will be noticed, however, that the species is peculiar in one respect, in that the

development of its sporangial hypha recalls that of Dimargaris, from the fact that the portion corresponding to the terminal spore appears to bud, as it were, from that corresponding to the basal spore after the latter has become almost fully formed and has assumed its more or less characteristic shape (*figs. 23, 24, 27, 28*).

Syncephalis Wynneæ and *S. pycnosperma* possess a further interest from a structural standpoint, in that they illustrate an extreme development of the type hitherto represented only by *S. fusiger.* Bainier, in his description of the latter species, distinguishes it as the type of a new genus which he calls Microcephalis, for the reason that the sporangial filaments arise in pairs from a common basal piece, corresponding to the basal spore or spores which bear similar relation to the erect spore-rows in species like *S. cordata* or *S. nodosa.* In *S. fusiger* this piece, instead of becoming converted into one or more spores, remains sterile and constitutes a specially developed organ, or secondary sporophore, which this author compares to the separable sterile piece on which the spore-rows are inserted in the species of Piptocephalis, although in the last instance this piece would seem to be more properly comparable with the swollen extremity of the fertile hypha in Syncephalis. So marked a differentiation of this secondary sporophore as is found in *S. Wynneæ* might seem to call for generic recognition were it not for such connecting links between this and the ordinary forms as are furnished by *S. pycnosperma* and *S. fusiger*, in view of which the character can hardly be considered of more than sub-generic value.

The zygospores of species of Syncephalis were first discovered by Van Tieghem in the common *S. cornu*, but, as far as the writer isaware, have been observed in only one other instance, those of *S. nodosa* having been described and figured by Bainier in his well-known "Étude sur les Mucorinées." The last mentioned species is very common in this country, and one seldom fails to obtain its zygospores in abundance whenever it grows on a copious substratum of other mucors. From the peculiarities

presented in the formation of these zygospores Bainier, in the paper above cited, separates it from other species of Syncephalis as the type of a distinct genus which he calls Calvocephalis; but since there are certain errors both in his figures and descriptions it may be of interest briefly to review the process in connection with the figures given in *Plate I.*

The zygospores of this species are always found in groups of from four or five to twenty or more, which are readily visible as white flecks scattered over the infested mass of mucors. The formation of the gametes is always preceded by the twisting together of two hyphæ, one of which forms a rather close spiral around the other, which is itself but slightly twisted. The latter ends in a swollen extremity (*figs. 18–20 y*) which becomes separated by a septum from the filament that bears it. The tip of the enveloping hypha winds about this swollen extremity, taking a last turn almost completely around it (as is shown, seen from above, in *fig. 18*). The helix thus formed is then separated from the hypha below by a septum (*figs. 18–19 z*), while its apex conjugates laterally or subterminally with the extremity of the inner hypha (*y*). As a result of this conjugation the spore arises, not between the two conjugating tips, but by budding from the helix just mentioned at a considerable distance from the point of conjugation and always close beside the septum (*z*). The mature zygospore is thus borne on a single short stalk which connects it with the helicoid gamete, while the filament below the septum (*z*) buds out at various points to form the curious bladder-like outgrowths which are apparently always associated with the zygospores of members of this genus (*figs. 20–21*). These outgrowths are even more copiously developed in the zygospores of *S. cornu* (*fig. 17*), but in *S. reflexa*, the zygospores of which do not seem to have been previously observed, they attain an even greater luxuriance (*figs. 15–16*). The zygospores themselves are irregularly bullate, about 21μ in diameter, and of a pale yellowish color. The material figured was found in a culture of mouse dung made some years since at New Haven, Conn.

Of the new species of Syncephalis previously referred to, three may be characterized as follows:

Syncephalis Wynneæ, nov. sp. *Plate I, figs. 5–12.*

Color white turning to pale straw color. Fertile hyphæ erect, straight, usually septate at the base, with well-marked rhizoids, tapering slightly towards the tip, distally enlarged, not abruptly, into a comparatively small head from all portions of the surface of which are produced secondary sporophores, the latter clavate, swollen at the tip, whence each gives rise to about a dozen sporangial filaments from each of which are produced two spores. Spores irregularly long-oval, usually slightly asymmetrical, involved at maturity in a mucus drop, 16–19 by 6μ. Secondary sporophore about 25μ long. Fertile hypha 400–475μ long, the head including spore *in situ* about 100–120μ in diameter.

On *Wynnea macrotis* Berk., Cranberry, North Carolina.

This species was found in a single instance, growing out of doors on a large clump of its remarkable host, which appears to be not uncommon in the Carolina mountains, and on which it seemed to be truly parasitic, growing not very densely and inducing a rapid decay in the large spoon-shaped apothecia. Attempts to cultivate it on potato-agar were unsuccessful, and no zygospores were found in the material examined. The species is especially noteworthy from the marked differentiation of its secondary sporophores, to which reference has been made above.

Syncephalis pycnosperma, nov. sp. *Plate II, figs. 32–38.*

Vegetative hyphæ slender with nodular anastomoses. Fertile hyphæ rather short and stout, commonly constricted at the basal septum, distally not abruptly enlarged to form a small head from all parts of which are produced numerous clavate secondary sporophores, the latter rarely furcate, distally gradually expanded and two to four-lobed, each lobe giving rise to a sporangial filament producing invariably three spores. Spores subrectangular or angular in section, thick-walled, involved in mucus at maturity, 13–16 by 7–8μ. Fertile hyphæ 300–350 by 25μ (towards the base) to 17μ (towards the apex). Secondary sporophores about 24μ long.

On dung of mice (New Haven, Conn.) and of sheep (Cambridge, Mass.).

This striking species has been met with but twice, growing not very abundantly on rather old cultures. Its peculiar spores and secondary sporophores, which have already been described in detail, serve to distinguish it at once from all other known species.

Syncephalis tenuis, nov. sp. *Plate II, figs. 22–31.*

Fertile hyphæ septate at the base, very elongate, tapering to a slender extremity which expands abruptly to form the fertile head, the latter somewhat flattened and bearing from six to many sporangial filaments arising from all parts of its upper surface or arranged in a more or less definite circle each producing two spores. Spores sub-cylindrical to asymmetrically oval, truncate or bluntly rounded, the cylindrical form 20–25 by 7μ, the oval form 25–27 by $10–11\mu$. Fertile hyphæ 500–700 by 7μ (at the base) to $4–5\mu$ (at the apex). Sporiferous head (without spores) $10–20\mu$ in diameter.

On Sphagnum in laboratory cultures, Kittery Point, Me.

This species is remarkable for its very slender habit and relatively large spores. It has made its appearance twice in cultures of Sphagnum on which were zygospores of an unknown zygomycete,[2] the orange yellow coherent waxy masses of which are not infrequently found in swampy places on this host, usually at the tip of its axis, occurring more rarely on other substances like decaying wood, etc. These zygospores, which are oblong and orange and are produced by budding upward from the point of union of the two gametes as in species of Syncephalis, although they are widely different in their color, form, and condition of aggregation from any of the known zygospores of this genus, may possibly be connected with the present species; but as all attempts to cultivate them under test conditions have thus far proved fruitless, and as the same cultures of Sphagnum on which they were growing have also yielded a new Martensella (in my opinion a zygomycete), two species of Mortierella, and a peculiar orange-colored Mucor, it is doubtful which, if any, of all these forms should be connected with them. The species is very inconspicuous, extremely delicate, and does not grow luxuriantly. The two varieties, the one with nearly cylindrical and the other with sub-oval spores, might be mistaken for distinct species, the latter variety producing fewer and larger spores borne on a smaller head terminating a more slender stalk; but the material examined appears to show much variability in these respects.

CAMBRIDGE, MASS.

[2] This fungus corresponds closely to the description of *Endogone xylogena* Schröter.

EXPLANATION OF PLATES I AND II.

The figures are reproduced by photolithography from camera drawings made with the combinations of Zeiss and Leitz objectives noted, and reduced about one-fourth in the reproduction.

Syncephalastrum racemosum Cohn.

FIG. 1. Young sporangium in which the contents has separated into seven masses separated by intersporal substance. The spore walls have not yet formed. One of the spores is lateral in position. $\frac{1}{18}$. oc. 4.

FIG. 2. Sporangium containing mature spores, some of which have escaped from the base. Two lie free within the sporangium; those near the extremity remaining side by side in the same position in which they were formed. $\frac{1}{18}$. oc. 4.

FIG. 3. Normal sporangium containing single row of superposed mature spores. $\frac{1}{18}$. oc. 4.

FIG. 4. Mature sporangium crushed, from which the spores are escaping. $\frac{1}{18}$. oc. 4.

Syncephalis (*Microcephalis*) *Wynneæ* Thaxter.

FIG. 5. General habit of fertile hypha showing head on which the spores are still *in situ*. C. oc. 2.

FIG. 6. A similar fertile hypha in which the spores have separated and adhere in a viscous mass. C. oc. 2.

FIG. 7. Tip of fertile hypha showing secondary sporophores from which numerous sporangial filaments are in process of development. J. oc. 2.

FIG. 8. Tip of mature fertile hypha showing secondary sporophores from which the spores have fallen. Seen in optical section. D. oc. 4.

FIG. 9. Secondary sphorophore bearing immature sporangial filaments. J. oc. 2.

FIG. 10. A similar sporophore in which the spores are nearly mature. D. oc. 4.

FIG. 11. Sporangial filament with its two spores nearly mature. J. oc. 4.

FIG. 12. Two mature spores. J. oc. 4.

Syncephalis reflexa Van Tieghem.

FIG. 13. Fertile hypha with the spores mature. C. oc. 4.

FIG. 14. The same, showing young sporangial filaments. C. oc. 4.

FIG. 15. Zygospore with sterile outgrowths from conjugating hyphæ J. oc. 2.

FIG. 16. The same. A zygospore seen in optical section. J. oc. 2.

Syncephalis cornu Van Tieghem.

FIG. 17. Zygospore with sterile outgrowths. J. oc. 2.

Syncephalis nodosa Van Tieghem.

FIG. 18. Gametes (x, y) seen from above in process of conjugation. The gamete x separated from the hypha which bears it by a septum (z). J. oc. 2.

FIG. 19. The same. A zygospore has begun to bud from the gamete (x) just above the septum (z). J. oc. 2.

FIG. 20. Conjugating filaments viewed laterally, the inner shown by dotted lines through the outer. Letters as in previous figures. The spiral filament which bears the gamete (x) producing sterile outgrowths. J. oc. 2.

FIG. 21. Two similar conjugating hyphæ, the inner not indicated by dotted lines.

FIG. 21*a*. Mature zygospore seen in optical section, its connection with the gamete (x) still attached. J. oc. 2.

Syncephalis tenuis Thaxter.

FIG. 22. General habit of mature fertile hypha, about one-sixth of its length indicated by dotted lines. D. oc. 4.

FIG. 23. Terminal portion of fertile hypha showing immature sporangial filaments, the terminal half of which is just beginning to form. D. oc. 4.

FIG. 24. Fertile head from which the basal halves of the sporangial filaments have been produced. D. oc. 4.

FIG. 25. Mature head of variety with larger spores. D. oc. 4.

FIGS. 26–29. Successive stages in development of sporangial filament. J. oc. 2.

FIG. 30. Separated spores of elongate type. J. oc. 2.

FIG. 31. Spore of large spored variety. J. oc. 2.

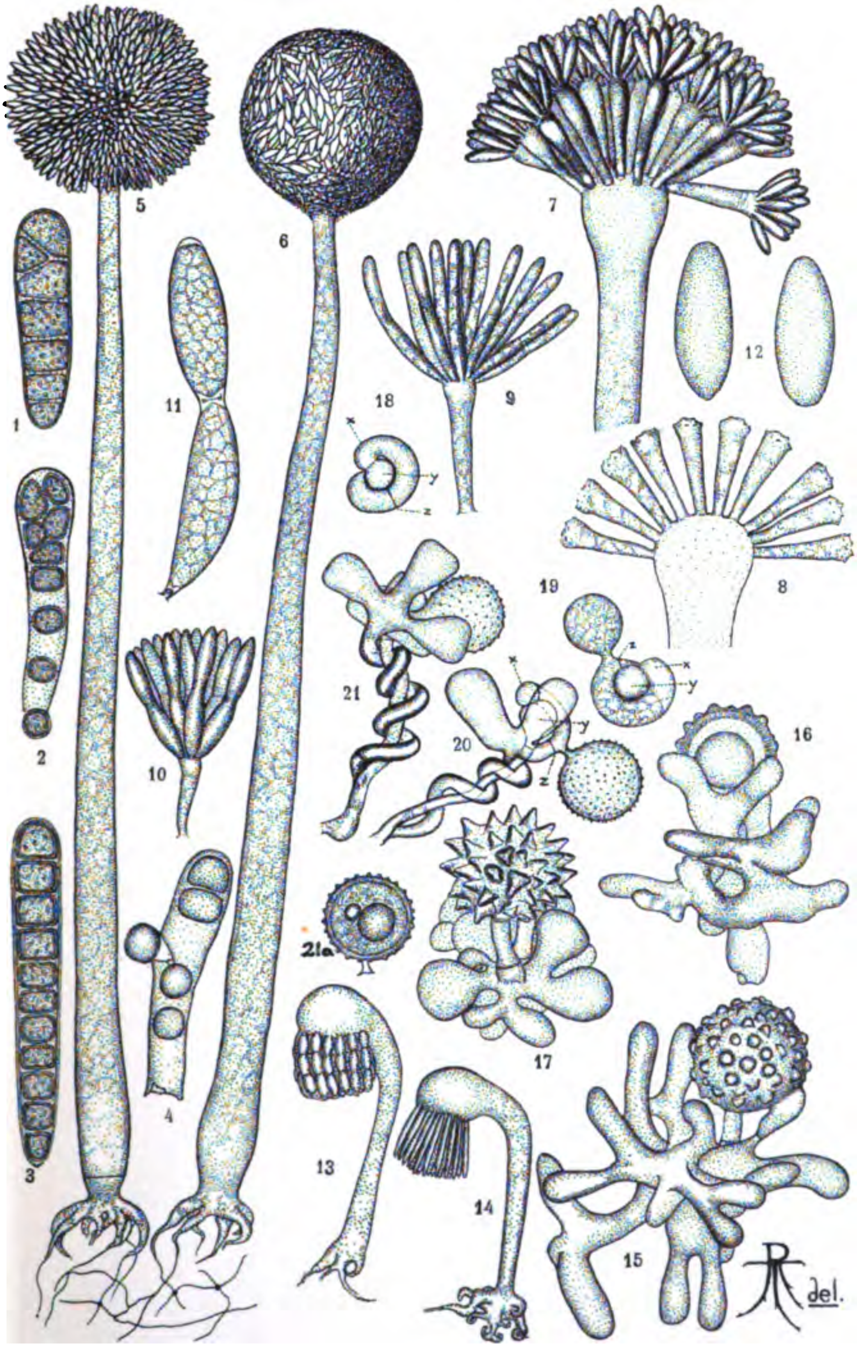
Syncephalis (*Microcephalis*) *pycnosperma* Thaxter.

FIG. 32. General habit of nearly mature fertile hypha. D. oc. 4.

FIG. 33. Terminal portion of fertile hypha showing numerous secondary sporophores from which the sporangial filaments are in process of formation. J. oc. 2.

FIG. 34. Mature head seen in optical section showing secondary sporophores, one of them furcate, from most of which the spores have fallen. J. oc. 2.

FIG. 35. Young sporangial filament showing two intermediary zones, the lower not completed, the upper nearly complete; *b*, the separation disk; *a*,



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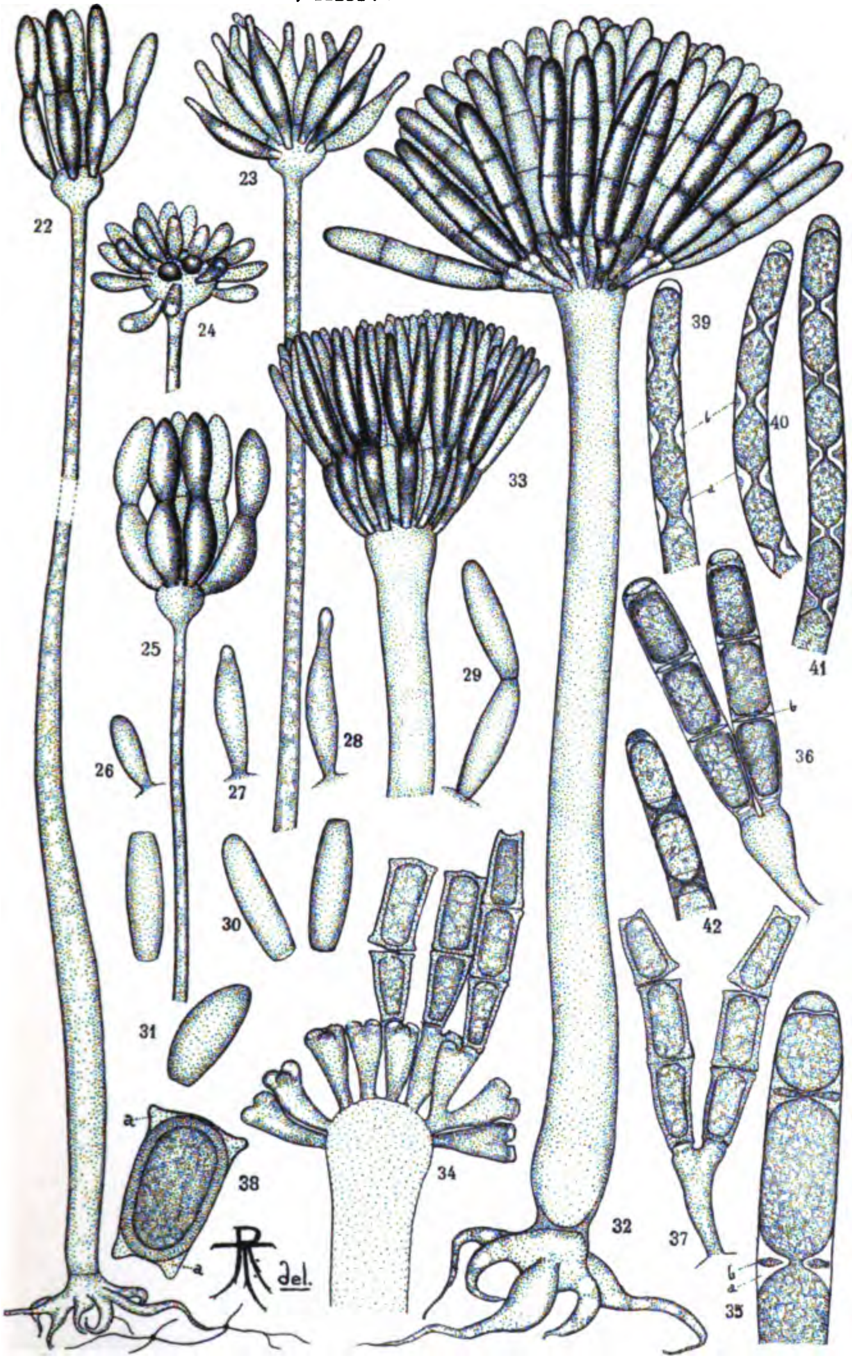
THAXTER on ZYGOMYCETES.



THAXTER on ZYGOMYCETES.

the indurated portion of the zone later forming part of the spore wall. $\frac{1}{16}$. oc. 4.

FIG. 36. More mature condition of the sporangial filaments; *b*, the separation disk. J. oc. 2.

FIG. 37. Mature sporangial filaments, the spores beginning to separate. J. oc. 2.

FIG. 38. Mature terminal spore showing persistent portion of intermediary zone (*a*, *a*). The spore wall more definitely distinguished than in nature. $\frac{1}{16}$. oc. 4.

Syncephalis, n. sp.

FIGS. 39–41. Successive stages in the formation of the intermediary zones in young sporangial filaments, showing gradual constriction and separation of the contents into parts corresponding to the spores. $\frac{1}{16}$. oc. 4.

FIG. 42. Terminal portion of sporangial hypha. The spores mature, separated by the intermediary zones, indicated in part by dotted lines, beginning to become mucilaginous. $\frac{1}{16}$. oc. 4.

THE DEVELOPMENT OF THE ANTHEROZOIDS OF ZAMIA.

HERBERT J. WEBBER.

IN the June number of this journal the writer discussed some of the phases of development of the pollen tube apparatus of *Zamia integrifolia*.[1] The generative cell was traced through its migration and division up to the time of the breaking down of the centrosome-like body. The discovery of motile antherozoids was also announced, but the method of their development was not explained.

Since then further observations have shown that each of the daughter cells, formed by the division of the generative cell, develops into a motile antherozoid, two thus being formed in each pollen tube; and that they are encircled by a spirally arranged band of cilia developed in a very novel way from the fragments of the centrosome-like body. In the present preliminary paper these features will be considered, together with a short account of observations on the movements of the antherozoids.

The membrane formed by the wall of the centrosome-like body in its disintegration evidently does not separate into two fragments, as I was at first inclined to think,[2] but forms a single somewhat contorted membrane or band which at this time lies free in the cytoplasm of the cell. In its further development this membrane becomes greatly extended in length, growing in such a manner as to form a spiral band or ribbon which meanwhile moves outward and becomes closely appressed against the *Hautschicht* of the cell. The first turn of the band is located near the equator of the cell nearly at right angles to the direc-

[1] WEBBER, HERBERT J.—Peculiar structures occurring in the pollen tube of Zamia. BOT. GAZ. **23**: 453. 1897.

[2] *Op. cit., Pl. XL, fig. 10.*

tion of the spindle formed in the division of the generative cell, and median sections in this stage show the deeply stained sections of the band lying on opposite sides of the cell (*fig. 1 b*). The band gradually elongates and finally forms five or six turns around the cell, which are arranged in a helicoid spiral on the surface, usually about opposite the side of the cell attached to the other antherozoid (*fig. 2*). Viewed from the apex of the spiral the turns, beginning at the apex, run in the direction opposite to that of the hands of a clock. No exceptions to this rule have been observed. In an early stage of its development very numerous protuberances can be discovered on the outer surface of the band. These gradually increase in length and become plainly visible by the time the band has formed one turn around the cell (*fig. 1*). They continue to grow in length and ultimately form the motile cilia of the mature antherozoids (*figs. 2* and *3*). The band varies considerably in width at various stages, becoming continually narrower as its development proceeds. In a mature stage, just before the antherozoids escape from the pollen tube, it is usually from 5 to 8μ wide. During the development of the spiral cilia-bearing band the cell becomes changed considerably in shape and appearance, as shown by comparing *fig. 2* with *fig. 1*. The band which, as explained above, finally comes to lie in close contact with the *Hautschicht* of the cell, is apparently invariably developed on the side of the cell opposite to the partition wall formed in

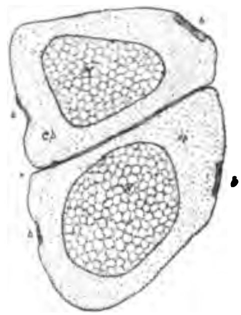


FIG. 1. Young antherozoid formed by the division of the generative cell, showing, in cross section, the spiral band which has developed one turn: *n*, nucleus; *cp*, cytoplasm; *b*, spiral band. × 200.

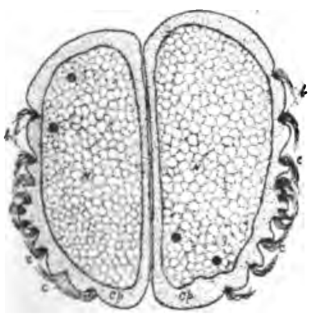


FIG. 2. Cross section of nearly mature antherozoid: *n*, nucleus; *cp*, cytoplasm; *b*, spiral band; *c*, cilia. ×200.

the division of the generative cell (*figs. 2* and *5 A*). The *Hautschicht* of the cell is bent in where the band is located, forming a deep spiral groove. By this the band is brought to the surface of the cell, but apparently remains covered by the *Hautschicht* through which the cilia appear to penetrate (*figs. 2* and *3*).

FIG. 3. Cross section of spiral band, showing attachment of cilia × 900.

While the generative cell and the antherozoids are developing as above described, the proximal ends of the pollen tubes, which, as noted in my previous paper,[3] grow downward through the apical tissue of the nucellus into a cavity formed in the prothallium above the archegonia, have increased in length until the ends almost or quite touch the neck cells of the archegonia, which protrude into the same cavity. It is interesting to note that the pollen tubes when they enter the prothallium cavity, which is filled with air, do not grow at random, but bend slightly outward and grow directly toward the archegonia. Frequently several turn toward the same archegonium. The end of the pollen tube is occupied by the proximal cell, described in my previous paper, which remains intact till the pollen tube bursts in the act of fecundation. The antherozoid cells at this stage invariably occupy a position in the pollen tube immediately above the proximal cell (*fig. 5 A*). The end of the tube is wider than the upper portion and is evidently under considerable tension. The protruding tip formed by the old pollen grain (*fig. 5 pg*) is plainly visible with a hand lens, and is evidently the point which first comes in contact with the neck cells of the archegonia. The neck cells are also distended and turgid, and are evidently easily broken. If in this stage the end of a pollen tube be touched very lightly with the flat side of a scalpel it bursts, and the antherozoids together with a drop of

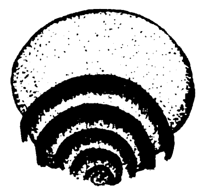
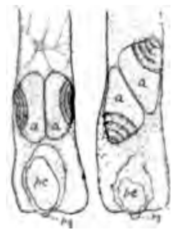


FIG. 4. Mature antherozoid. × 90.

[3] *Op. cit.*, 455, *Pl. XL*, *fig. 6*.

the watery contents of the pollen tube are quickly forced out, and the pollen tube immediately shrivels up into a shapeless mass. This is probably what happens naturally in the course of fecundation. The pollen tube evidently grows down until the end is forced against the neck cells, when the tube bursts, discharging the mature antherozoids and the watery contents of the tube which supplies a drop of fluid in which the antherozoids can swim. I have several times observed the antherozoids after they were discharged over the archegonia, but studying them in this position is difficult and unsatisfactory. For purposes of microscopic study the pollen tubes were carefully cut off some distance above the antherozoid cells and placed in water, but this proved unsatisfactory, as the antherozoids soon died and burst, evidently from the difference in density of water and the contents of the pollen tube. Solutions of cane sugar of several strengths were then tried, and a 10 per cent. solution proved thoroughly satisfactory. By the use of this solution I was able to keep the antherozoids living and moving for a considerable time, usually from thirty to sixty minutes, and in one case two hours and forty-four minutes When mature pollen tubes are placed in sugar solution the proximal cell, protoplasm, etc., can at first be seen to have their normal shape, the antherozoid cells usually still adhering to each other (*fig. 5 A*). In a few minutes, however, when the sugar has had time to diffuse into the pollen tube, the proximal cell and protoplasm break down into a shapeless mass, and the antherozoids, under the stimulation of the sugar solution, gradually begin to awaken into life, as it were. The cilia begin to move, and the cells round up and slowly pull apart (*fig. 5 B*). When swimming free without pressure the antherozoids are slightly ovate, nearly round, or compressed spherical (*fig. 4*).



A B

FIG. 5. Separation of antherozoids under influence of 10 per cent. sugar solution: *A*, mature pollen tube immediately before fecundation placed in sugar solution; *B*, the same tube about five minutes later; *pg*, remains of pollen grain at lower end of tube; *pc*, proximal cell; *a*,*a*, antherozoids. ×50.

They vary greatly in size, but are commonly longer than broad, ranging in length from 258 to 332μ and in width from 258 to 306μ. The antherozoids of Ginkgo, as described by Hirase,[4] are egg-shaped and 82μ long by 49μ wide. Compared with these, the antherozoids of Zamia are surprisingly large, being plainly visible to the unaided eye. In Cycas, according to Ikeno, they are somewhat larger than in Ginkgo. I judge from this that they are also much larger in Zamia than in Cycas. The numerous cilia which are developed from the spirally arranged band, as described above, give the pointed end of the antherozoid a striking helicoid appearance. There is no free tail in Zamia, as is said by Hirase to occur in Ginkgo. The nucleus is very large (*fig. 2 n*), occupying a large portion of the body, and is surrounded on all sides by a thin layer of cytoplasm (*fig. 2 cp*). The vibrations of the cilia in vigorous antherozoids are exceedingly rapid and difficult to study. Judging from observations made on certain antherozoids just starting motion and others which had nearly exhausted their energy, there would seem to be a rhythmic contraction of the cilia which passes quickly from one end of the band to the other. A tremulous vibration of the cilia, apparently independent of the rhythmic contraction, can be observed in the weaker motion of extreme youth and age. Whether this occurs in the period of vigorous rapid motion could not be determined. The motion of the antherozoid is comparatively slow and sluggish. In pollen tubes placed in sugar solution the two antherozoids frequently move around very vigorously, bumping against each other and the wall of the pollen tube. They seldom escape from the upper cut end of the pollen tube, although they as frequently swim toward this end of the tube as the other end, so far as could be observed. In a number of instances the pollen tubes were cut so that the antherozoids escaped and their unobstructed motion was thus observed. The *Hautschicht* of the antherozoid is very tender, however, and is commonly broken in attempting to remove the latter from the

[4] HIRASE, DR. S.—Untersuchungen über das Verhalten des Pollens von *Ginkgo biloba*. Bot. Centralb. **69**: 34. 14 Ja. 1897.

tube. The motion when swimming free in the sugar solution is in no way different from the action observed in the pollen tube. The general motion is a continuous rotation of the body, always in the same direction around an axis passed through the apex of the helicoid spiral. Viewed from the head end or apex of the spiral the rotation is in the direction of the hands of a clock, and contrary to the turns of the spiral band. They roll round, first here, then there, resembling in this respect the motion of Pandorina. After moving about rapidly for from five to ten minutes they usually cease all progressive motion, but continue to rotate for a considerably longer period. The rotary motion also soon ceases, but the cilia continue to vibrate for a considerably longer time.

In fecundation the entire antherozoid unchanged swims into the archegonium, passing between the ruptured neck cells. Several antherozoids commonly enter each archegonium, from two to three having been found in almost every archegonium examined, and in one case four. Only one of these takes part in fecundation, and the others may be found presenting a perfectly normal appearance or in some stage of disintegration.

The study of the centrosome-like body, which formed the main feature of my previous paper, has continued to grow in interest as the investigation has progressed. No case is known, so far as I am informed, where true centrosomes fulfill such functions as are performed by the centrosome-like body in Zamia. The very large size of the organ; the loss of the radiating filaments of kinoplasm in an early stage of the division of the generative cell; the swelling and breaking down of the body in the anaphases of the same division; the disintegration of the central part of the body; and the final growth of the membrane, formed by the broken wall of the body, into the spiral band which bears the motile cilia of the antherozoid—are features and functions peculiar to the centrosome-like body of Zamia. It is interesting in this connection to note that the substance of the band stains a dense blue black with Heidenhain's iron hæmatoxylin, which is primarily a centrosome stain,

although it also stains nucleoli deeply. The method of anthero-zoid formation found in Zamia is also very different from any known case, so far as I can learn, but is probably similar to what occurs in Ginkgo and Cycas.

In a future number of this journal the writer hopes to discuss the phenomena of fertilization in Zamia together with further notes on the homologies and functions of the centrosome-like body.

U. S. DEPARTMENT OF AGRICULTURE,
July 3.

MEXICAN FUNGI.

E. W. D. HOLWAY.

THE following species were collected on my vacation trip, in 1896. The Uredineæ were determined by Dr. Dietel, and descriptions sent me in German, which I have translated. I am indebted to C. G. Pringle, L. M. Underwood, J. N. Rose, and F. L. Scribner for determinations of the host plants. To Mr. Pringle's kind assistance and advice in Mexico the size of the collection is largely due. My time was almost entirely devoted to the Uredineæ and Ustilagineæ.

Uromyces Epicampus Diet. & Holw., n. sp.—Sori epiphyllous, between the veins, linear, naked: uredosori yellowish-brown; spores mostly round, 28–32μ; epispore thickly set with short spines; germ-pores numerous, scattered over the whole surface: teleutosori black-brown; spores round or ovate, rarely conical at apex, 26–35 by 20–26μ, chestnut-brown, epispore rather thin, apex darker and strongly thickened (5–7μ); pedicel firm, up to 100μ long.—On *Epicampes macroura*, Esclava, near City of Mexico, Sept. 30.

UROMYCES PECKIANUS Farlow.—On *Eragrostis Purshii*, Guadalajara, Oct. 11; *E. lugens*, var. *major*, Rio Hondo, near City of Mexico, Oct. 4; *Muehlenbergia*, near City of Mexico, Oct. 2.

UROMYCES EUPHORBIÆ C. & P.—On *Euphorbia* sp., Cuernavaca, Sept. 22; *Euphorbia* (2 sp.), near City of Mexico, Oct. 7.

Uromyces globosus Diet. & Holw., n. sp.—Sori hypophyllous, of medium size, scattered or sometimes crowded, naked, black, pulverulent: teleutospores spherical, 30–36μ, or broadly ovate, and up to 40μ, opaque, dark brown, closely verrucose, apex lighter, yellowish-brown; pedicel longer than the spore, easily separating at the base from the leaf, colorless, 10–12μ wide,

hollow, attached to the spore by a brown spreading collar: uredospores (a few found among the teleutospores) ovate, about 36μ long, shortly aculeate, thickened at apex, brown, lighter towards the base.—On some euphorbiaceous tree, Cuernavaca, Sept. 22.

Uromyces Solani Diet. & Holw., n. sp.—Sori hypophyllous, on small yellow spots, scattered, small, naked: uredospores obovate, 23–33 by 18–21μ, pale-brown, echinulate, with four equatorial germ-pores: teleutospores clavate, or narrowly ovate, narrowed towards the pedicel, mostly beak-like at apex, 30–48 by 10–17μ, smooth, light chestnut-brown, colorless towards apex.—On *Solanum appendiculatum*, Cuernavaca, Sept. 23.

UROMYCES CALADII (Schw.) Farlow.—On *Arisæma Dracontium*, Cuernavaca, Sept. 23.

UROMYCES BREVIPES (B. & Rav.).—On *Rhus Toxicodendron*, Cuernavaca, Sept. 23. Not *U. terebinthi* (DC.), to which it is usually referred, the uredospores being quite distinct.

UROMYCES STRIATUS Schröt.—II only. On *Medicago lupulina* and *M. denticulata*, near Tula, Oct. 6; *M. lupulina*, near City of Mexico, Oct. 7.

Uromyces Mexicanus Diet. & Holw., n. sp.—Sori mostly hypophyllous, also on the pedicels and stems; spots inconspicuous, brown or yellow, often wanting: uredosori scattered or in irregular groups, cinnamon-brown; spores broadly elliptical or globose, 18–23 by 17–21μ, pale brown, echinulate: teleutosori pulvinate, black, naked, on the leaves small, on the stems and pedicels larger and elongated; spores ovate, rarely almost globose, thickened at apex and often narrowed to a short conical point, 23–30 by 18–22μ, smooth, chestnut-brown; pedicel colorless, slender, up to 100μ long, narrowed towards the base.—On *Desmodium*, City of Mexico, Oct. 9; Guadalajara, Oct. 11; Cuernavaca, Sept. 22.

Uromyces obscurus Diet. & Holw., n. sp.—Æcidia hypophyllous, scattered, at first sunk in the parenchyma, then erumpent, without pseudoperidia, flat, orange-red; æcidiospores when fresh yellowish-red, globose or elliptical, 17–25 by 17–20μ, smooth:

uredo- and teleutospores intermixed in black sori, on both sides of the leaves and on the stems and pedicels: uredospores globose or elliptical, 20–30 by 20–25μ, yellowish-brown, echinulate: teleutospores elliptical, ovate or globose, 27–38 by 23–27μ, chestnut-brown, apex with a broad pale-brown papilla, or rarely with only a cucullate thickening; pedicel as long as the spore or somewhat longer, rather fragile.—On *Phaseolus*, Cuernavaca, Sept. 23; near Tula, Oct. 5; Guadalajara, Oct. 12 and 13.

UROMYCES PHASEOLI (Pers)?—Uredo only. On Phaseolus cult., Cuernavaca, Sept. 22.

Uromyces tenuistipes Diet. & Holw., n. sp.—Sori small, hypophyllous, scattered, forming red spots on the upper side of the leaf: uredosori brown; spores globose or elliptical, 21–24 by 18–22μ, pale brown, echinulate: teleutosori black; spores mostly globose, 22μ, epispore thick, apex with a small shallow depression, not much thickened; pedicel very long and slender, rather fragile.—On *Desmodium*, Esclava, near City of Mexico, Sept. 29.

Uromyces Galphimiae Diet. & Holw., n. sp.—Sori small, naked, scattered over both sides of the leaf: uredosori cinnamon-brown; spores obovate or elliptical, 28–36 by 22–32μ, with a pale-brown shortly echinulate membrane and golden-yellow contents: teleutosori black; spores ovate or elliptical or almost globose, narrowed at apex to a small obtuse point, 35–45 by 23–33μ, epispore chestnut-brown, closely verrucose, thickened at apex; pedicel longer than the spore, fragile.—On *Galphimia Humboltiana*, Guadalajara, Oct. 12.

Uromyces Jatrophae Diet. & Holw., n. sp.—Spots yellow, of irregular outline or none, sori hypophyllous: teleutosori black, small, scattered or united in irregular groups: uredospores (only a few seen) elliptical, 21–25 by 17–22μ, with a colorless verrucose membrane; teleutospores globose or broadly elliptical, coarsely verrucose, dark chestnut-brown, apex terminating in a brown papilla, 27–33 by 23–29μ; pedicel about as long as the spore, fragile.—On *Jatropha multifida*, Guadalajara, Oct. 12.

Uromyces Ægopogonis Diet. & Holw., n. sp.—Sori hypophyllous, rarely epiphyllous: uredosori oblong or linear, ochreous;

spores mostly globose or subovate, 20–24μ in diameter, pale-brown, echinulate, with about 8 germ-pores: teleutosori black, elliptic or somewhat linear, pulvinate; spores uniformly globose, 22–27μ in diameter, chestnut-brown, smooth, apex broadly hooded (5–7.5μ thick) and darker colored; pedicel brown, firm, long.— Near *U. Peckianus*, from which it is distinguished by the round teleutospores.—On *Ægopogon cenchroides*, near City of Mexico, Oct. 1.

Puccinia Zexmeniæ Diet. & Holw., n. sp.— Sori scattered, on both sides of the leaf: uredospores elliptical to globose, 20–22 by 17–20μ, bright brown, echinulate: teleutospores elliptical, rounded at both ends, not at all or only slightly constricted, 35–45 by 25–33μ; epispore chestnut-brown, 4–5μ thick, apex not at all thickened or sometimes with a small cucullate thickening; membrane closely reticulated with narrow ridges; pedicel longer than the spore, thin, colorless, not rarely inserted on the side, easily breaking from the leaf.— On *Zexmenia podocephala*, Guadalajara, Oct. 12.

Puccinia opaca Diet. & Holw., n. sp.— Sori small, black, scattered, on both sides of the leaf: uredospores elliptical, 18–20 by 16–17μ, light-brown, echinulate: teleutospores elliptical, rounded at both ends, slightly constricted, 30–36 by 24–28μ, dark chestnut-brown, mostly not thickened at apex; membrane coarsely reticulated with broad ridges; pedicel colorless, to 90μ long, occasionally inserted on the side, easily separating from the leaf.—On *Zexmenia ceanothifolia*, Guadalajara, Oct. 12.

The two preceding species, although much alike, are easily distinguished by the size of the teleutospores and the markings of the membrane.

Puccinia tageticola Diet. & Holw., n. sp.— Sori on both sides of the leaves, scattered, small, on the stems and pedicels, large, pulvinate, naked: uredosori brown; spores, elliptical, obovate, or globose, 24–31 by 17–24μ, light-brown, echinulate: teleutosori black; spores elliptical, rounded at both ends, slightly constricted, 44–52 by 30–35μ, epispore smooth, chestnut-brown, apex with a broad, hooded, often hyaline thickening; pedicel to

100μ long, colorless, rather firm.—On *Tagetes tenuifolia*, Guadalajara, Oct. 12.

Puccinia (UROPYXIS) **Daleæ** Diet. & Holw., n. sp.—Sori on both sides of the leaves, scattered or confluent in round groups, from dot-like to medium sized: uredosori cinnamon-brown or often colorless, containing hooked paraphyses; uredospores globose or broadly elliptical, 22–25 by 20–22μ, pale-brown, finely echinulate, with numerous scarcely visible germ-pores: teleutosori black-brown, pulvinate; teleutospores slightly constricted, rounded at both ends, 35–47 by 24–28μ, epispore chestnut-brown with a colorless verrucose envelope, 2–2.5μ thick, and two germ-pores in each cell; pedicel hyaline, about half as long as the spore, thick (in water swelling up to 18μ).—On *Dalea*, near Tula, Oct. 5; near Tacubaya, Oct. 7.

Puccinia (UROPYXIS) **Nissoliæ** Diet. & Holw., n. sp.—Uredo not seen: teleutosori mostly hypophyllous, scattered, small or medium sized, black-brown, pulverulent; spores rounded at both ends, scarcely constricted, 32–40 by 25–27μ; membrane chestnut-brown, with a hyaline verrucose envelope 1–2μ thick, and two germ-pores in each cell; pedicel hyaline, up to 25μ long and 5–6μ thick.—On *Nissolia confertiflora*, Guadalajara, Oct. 12.

Puccinia (UROPYXIS) **Eysenhardtiæ** Diet. & Holw., n. sp.—Spots yellowish or none; sori punctiform, hypophyllous, scattered: uredosori whitish, surrounded by hyaline hooked paraphyses; spores broadly elliptical or globose, 15–20 by 15–17μ, pale-brown, echinulate: teleutosori black-brown; spores rounded at both ends, slightly constricted, 38–45 by 25–28μ, chestnut-brown, with a thin verrucose hyaline envelope, and two germ-pores in each cell; pedicel mostly globose, 15–18μ in diameter, hyaline.—On *Eysenhardtia orthocarpa*, near City of Mexico, Oct. 1.

These three species can be distinguished with certainty only by the peculiarities of the pedicels, and, so far as they are known, by the uredospores.

Puccinia Tripsaci Diet. & Holw., n. sp.—Sori on both sides of the leaves, at first covered by the epidermis, at length erumpent, somewhat linear: uredosori cinnamon-brown, spores glo-

bose or elliptical, 30–37 by 28–33μ, epispore up to 4μ thick, chestnut-brown, echinulate, with 4 germ-pores: teleutospores elliptic or obovate, rounded at both ends, with a hooded thickening at apex, slightly constricted, smooth, brown, 33–41 by 20–25μ; pedicel longer than spore, firm, brownish.—On *Tripsacum dactyloides*, near City of Mexico, Oct 2.

PUCCINIA CORONATA Cda.—On *Bromus*, near Tula, Oct. 5.

Puccinia Cenchri Diet. & Holw., n. sp.—Sori very small, hypophyllous, scattered: uredosori surrounded by the ruptured epidermis; spores obovate or elliptical, 36–45 by 30–35μ, brown, echinulate, with equatorial germ-pores: teleutosori covered by the epidermis, black; spores oblong, mostly clavate, apex truncate or irregularly angled, sometimes constricted, narrowed or rounded at base, 40–53 by 18–25μ, epispore smooth, brown, strongly thickened at apex; pedicel very short, brown.—On *Cenchrus multiflorus*, Guadalajara, Oct. 12.

PUCCINIA VEXANS Farlow.—On *Bouteloua racemosa*, near Tula, Oct. 6.

PUCCINIA SUBNITENS Diet.—On *Aristida dispersa*, near Torreon, Oct.

Puccinia versicolor Diet. & Holw., n. sp.—Spots epiphyllous, purple-red, or brown and yellow; sori hypophyllous, oblong or linear: uredosori yellow, surrounded by the ruptured epidermis; spores ovate, 30–40 by 25–31μ, epispore very thick, colorless, with short spines, contents irregularly branched, or often star-shaped: teleutosori firm, pulvinate, black, surrounded by the ruptured epidermis; spores elliptical, scarcely constricted, rounded at both ends, smooth, chestnut-brown, apex variously thickened (generally not over 8μ), 35–45 by 27–33μ; pedicel hyaline, firm, up to 130μ long.—On *Andropogon melanocarpus*, Guadalajara, Oct. 12.

Puccinia Setariæ Diet. & Holw., n. sp.—Sori mostly epiphyllous, elliptic or sublinear; uredosori cinnamon-brown, naked; spores elliptical or almost globose, sometimes angular, 28–38 by 22–29μ, with a thick closely verrucose epispore, and 6–8 germ-pores, dirty yellow-brown: teleutosori pulvinate, black; spores

elliptical or obovate, rarely fusiform, not at all or only rarely constricted, rounded at both ends, rarely conical at apex, 35–48 by 24–33μ, epispore smooth, chestnut-brown, apex with a broad hooded thickening (7.5–13μ); pedicel thick, firm, up to 100μ long, hyaline or pale brown.—On *Setaria imberbis*, City of Mexico, Sept. 30.

Puccinia atra Diet. & Holw., n. sp.—Sori mostly hypophyllous: uredosori mostly linear, up to 5^{mm} long, naked, pulverulent, cinnamon-brown; spores elliptical or ovate, 27–35 by 21–25μ, closely covered with small warts, brown: teleutosori punctiform or linear, scattered or clustered, naked, black; spores elliptical, rounded at both ends, scarcely constricted, smooth, chestnut-brown, apex with hooded thickening (about 5μ), 31–38 by 21–26μ; pedicel rather firm, up to 85μ long, hyaline, often brownish next the spore.—On *Setaria Grisebachii*, Rio Hondo, near City of Mexico, Oct. 4.

Distinguished from *P. Setariæ* by the smaller spores.

PUCCINIA EMACULATA Schw.—Uredo only. On *Panicum halciforme*, near Tula.

Puccinia Esclavensis Diet. & Holw., n. sp.—Sori on both sides of the leaves, but mostly epiphyllous, small to medium sized, globose to linear, often confluent on the stems; uredosori cinnamon-brown; spores elliptical, ovate, or globose, 30–43 by 24–33μ, yellow-brown to chestnut-brown, very closely covered with small warts, and with 4 equatorial germ-pores: teleutosori black-brown, pulvinate, naked; spores elliptical, rarely obovate, not at all or only slightly constricted, rounded at both ends; apex with a broad hooded thickening, 32–41 by 23–28μ, smooth, dark chestnut-brown; pedicel up to 160μ long, hyaline.—On *Panicum bulbosum*, Esclava, near City of Mexico, Oct. 3.

PUCCINIA NIGROVELATA Ell. & Tracy.—On *Cyperus*, City of Mexico, Sept. 30.

Puccinia cinnamomea Diet. & Holw., n. sp.—Sori in irregular or often linear groups, hypophyllous, punctiform, pulvinate, cinnamon-brown: teleutospores oblong, 28–38 by 14–20μ, constricted, both ends rounded, with a hooded or rarely conical

thickening at apex; membrane pale cinnamon-brown, smooth; pedicel as long as the spore, or somewhat shorter, firm, hyaline. —On a small terrestrial orchid, Cuernavaca, Sept. 23.

The spores germinate on the leaf, as soon as mature.

PUCCINIA BACCHARIDIS Diet. & Holw.—On *Baccharis cærulescens*, near Tula, Oct. 6.

Puccinia Amphilophii Diet. & Holw., n. sp.—Sori hypophyllous (rarely epiphyllous), small or medium sized: uredosori brown; spores ovate or broadly elliptical, 23–27 by 20–24μ, with large spines, yellow-brown: teleutosori black, pulverulent; spores broadly elliptical, rounded at both ends, when dry depressed at apex and base, moderately constricted, 33–40 by 26–30μ; membrane not at all thickened at apex or slightly hooded, chestnut-brown, with short spines: pedicel as long as the spore or very little longer, hyaline, hollow, mostly with a few appendages on the sides at the base, readily breaking at base from the host plant.—On *Amphilophium*, Cuernavaca, Sept. 22.

The peculiar pedicels show that this species is closely related to *P. appendiculata* Wint., but it may readily be distinguished by the form of the spores, the echinulate epispore, and particularly by the appendages occurring only at the base of the pedicels.

PUCCINIA APPENDICULATA Wint. (*P. ornata* Hark.; *P. medusæoides* Arthur).—On *Tecoma stans*, Guadalajara, Oct. 12.

Puccinia vacua Diet. & Holw., n. sp.—Sori hypophyllous, occasionally epiphyllous, scattered: uredosori pale-yellow; spores broadly elliptical or ovate to globose, 22–29 by 20–25μ; membrane almost hyaline, echinulate: teleutosori dark brown; spores elliptical, rounded at both ends, rarely narrowed towards the pedicel, slightly constricted, closely verrucose, brown, hooded at apex, 35–60 by 23–28μ, pedicel up to 80μ long, hyaline, not very firm.—On *Lobelia*, Cuernavaca, Sept. 23.

The teleutospores germinate as soon as mature. Spores have a thicker membrane, and are much larger than those of *P. Lobeliæ* Ger.

Puccinia Triumfettæ Diet. & Holw., n. sp.—Spots yellow, becoming black in the center, round or irregular: sori hypophyllous, confluent in irregular groups, firm, pulvinate, almost

globose, dark-brown: teleutospores elliptical, oblong, or rarely clavate, either rounded at both ends or narrowed towards the pedicel, often shortly conical at apex, little or not at all constricted, 27–37 by 13–19μ, epispore smooth, pale brown, strongly thickened at apex (3–6μ).—On *Triumfetta semitriloba*, Cuernavaca, Sept. 23.

PUCCINIA CALOCHORTI Pk.—On *Calochortus flava*, near City of Mexico, Oct. 2.

PUCCINIA VIGUIERÆ Pk.—On *Viguiera picta* and *V. helianthoides*, near Tula, Oct. 6; *V. excelsa*, Rio Hondo, near City of Mexico, Oct. 4.

I am indebted to Professor Peck for comparison with the type.

PUCCINIA ELYTRARIÆ P. Henn.—On *Elytraria tridentata*, Cuernavaca, Sept. 23; Guadalajara, Oct. 12.

PUCCINIA ARECHAVALETÆ Speg.—On *Cardiospermum Halicacabum*, Guadalajara, Oct. 12; Cuernavaca, Sept. 23; near Tula, Oct. 5.

PUCCINIA PRUNI-SPINOSÆ (Pers.)—On *Prunus serotina*, near Tula, Oct. 6; Rio Hondo, near City of Mexico, Oct. 4.

PUCCINIA HETEROSPORA B. & C.—On *Abutilon* (2 sp.), Cuernavaca, Sept. 23; *Sida*, Cuernavaca, Sept. 23; *Anoda*, Guadalajara, Oct. 12.

PUCCINIA EUPHORBIÆ P. Henn.—On *Euphorbia*, Cuernavaca, Sept. 23.

Differs somewhat from specimens on *Euphorbia cotinifolia* collected by Mr. Pringle (valley of Oaxaca), which have spores 60–75μ long. In these specimens the spores are only 40–55μ long, and may therefore be called var. **minor**, n. var. The spores of the type, from Abyssinia, are 54–65μ long.

PUCCINIA IPOMEÆ-PANDURANÆ (Schw.)?—On *Ipomœa*, Cuernavaca, Sept. 22.

PUCCINIA LATERITIA B. & C.—On *Bouvardia*, Cuernavaca; *Crusea*, Cuernavaca.

PUCCINIA CONOCLINII Seymour.—On *Eupatorium Schaffneri*, near Tula, Oct. 6; *Ageratum*, Guadalajara, Oct. 11.

Puccinia Tithoniæ Diet. & Holw., n. sp.—Sori mostly hypophyllous, rather small, scattered: uredosori cinnamon-brown,

pulverulent; spores globose or ovate, 24–30 by 20–26μ; membrane thin, brown, with very short spines: teleutosori black; spores elliptical or ovate, rounded at both ends, slightly constricted, 38–52 by 22–27μ, smooth, chestnut-brown, hooded at apex or rarely with a conical thickening, mostly paler in color; pedicel hyaline, longer than the spore, rather firm.—On *Tithonia cubiflora*, near City of Mexico, Oct. 2; *T. tagetiflora*, Guadalajara, Oct. 12.

This species is much like *P. Helianthi* Schw., but the spores are darker, average smaller, and the septum is less thickened at the sides.

Puccinia Bidentis Diet & Holw., n. sp.—Sori mostly hypophyllous, scattered, small, dark-brown, on faint yellow spots: teleutospores partly 2-celled, but mostly 1-celled, the latter elliptical, ovate or globose, 19–30 x 17–23μ; the 2-celled spores greatly variable in form and size, elliptical or oblong, rarely narrowed to the pedicel, slightly constricted, 24–38 by 15–25μ, chestnut-brown, finely punctate; pedicel firm, mostly longer than the spore, colored above.—On *Bidens*, Cuernavaca, Sept. 23.

Puccinia Melampodii Diet. & Holw., n. sp.—Spots pale yellow or brownish; sori hypophyllous, small, pulvinate, black-brown, mostly in small irregular groups: teleutospores oblong or fusiform, rounded or narrowed to a conical point at apex, narrowed towards the pedicel, moderately constricted, 42–60 by 15–20μ, epispore smooth, brown, apex strongly thickened (5–10μ); pedicel firm, up to 27μ long.—On *Melampodium*, Cuernavaca, Sept. 25.

Puccinia Enceliæ Diet. & Holw., n. sp.—Sori hypophyllous, scattered, naked: uredosori brown; spores elliptical or globose, 20–25 by 19–23μ, brown, echinulate: teleutosori black-brown; spores elliptical or obovate, rounded at both ends, very slightly constricted, 31–42 by 23–27μ; membrane smooth, chestnut-brown, apex with a light flat hood about 7μ thick; pedicel longer than the spore, hyaline, moderately firm.—On *Encelia Mexicana*, Cuernavaca, Sept. 25.

This species is much like *P. Helianthi* Schw., of which it is perhaps only a form. The teleutospores, however, average considerably smaller.

PUCCINIA GRANULISPORA Ell. & Ev.—On *Allium*, Cuernavaca, Sept. 26.

PUCCINIA OXALIDIS Diet. & Ellis.—On *Oxalis*, common near City of Mexico, Sept. 30.

Puccinia salviicola Diet. & Holw., n. sp.—Sori on both sides of the leaves, scattered, medium sized, at first covered by the epidermis, pulverulent: uredosori cinnamon-brown; spores globose, ovate or elliptical, 22–37 by 20–30μ, light-brown, echinulate, with 2 germ-pores: teleutospores in black sori, elliptical, rounded at both ends, or short conical at apex, not at all or slightly constricted, 35–44 by 25–33μ, apex with a thick hooded or broadly conical thickening, very slightly verrucose, chestnut-brown; pedicel longer than the spore, hyaline, narrower towards the base.—On *Salvia glechomæfolia*, near City of Mexico, Sept. 26.

Differs from *P. nigrescens* Pk. in its larger teleutospores and thicker, nearly smooth membrane.

Puccinia Apocyni Diet. & Holw., n. sp.—Sori epiphyllous, bright brown, closely clustered in round groups, on yellow circular spots 2–4^{mm} in diameter: teleutospores oblong, apex shortly conical or rounded, distinctly constricted, lower cell narrowed or rounded, 32–50 by 16–23μ, pale-brown, smooth, apex strongly thickened and lighter colored; pedicel firm, not longer than the spore.—On *Apocynum androsæmifolium*, Esclava, near City of Mexico, Oct. 3.

Puccinia Mexicana Diet. & Holw., n. sp.—Spots reddish purple, surrounded by a broad yellow margin, circular, 3–5^{mm} broad; sori pulvinate, small, thickly clustered, dark-brown: teleutospores long elliptical to fusiform, apex mostly conical pointed, rarely rounded, lower cell rounded or narrowed to the pedicel, only slightly constricted, 38–50 by 16–23μ; membrane yellow-brown, smooth, apex thickened; pedicel longer than the spore, firm, hyaline.—On *Penstemon campanulatus*, Esclava, near City of Mexico, Sept. 29.

The spores are more slender, lighter colored, and have a thinner membrane than those of *P. Penstemonis* Pk.

Puccinia pinguis Diet. & Holw., n. sp.—Sori scattered, on both sides of the leaf, but mostly hypophyllous, small: uredosori brown, naked, pulverulent; spores globose or ovate, 28–33 by 24–30μ, echinulate, brown, with 2 germ-pores; teleutosori black, pulverulent; spores broadly elliptical, rounded at both ends, scarcely constricted, 48–53 by 33–40μ, apex with a short hyaline hood (a similar one often over the germ-pore of the lower cell); membrane 5–6μ thick, smooth, chestnut-brown; pedicel easily separating from the leaf, longer than the spore, hyaline.—On *Brickellia*, Rio Hondo, near City of Mexico, Oct. 3.

Puccinia Guillemineæ Diet. & Holw., n. sp.—Sori mostly epiphyllous, round, 0.5–1^{mm} in diameter, thick, sometimes confluent, dark-brown: teleutospores elliptical, rounded at both ends, very little constricted, 29–37 by 20–23μ, epispore deep chestnut-brown, smooth, apex strongly thickened (4–7μ); pedicel long, fragile.—On *Guilleminea*, near City of Mexico, Oct. 7.

PHRAGMIDIUM SUBCORTICIUM (Schrank) Wint.—On *Rosa* cult., Guadalajara, Oct. 14.

Coleosporium Viguieræ Diet. & Holw., n. sp.—Uredosori orange-yellow, small, scattered, hypophyllous, causing irregular yellow spots; spores in chains, elliptical or globose, 19–25 by 15–20μ, epispore hyaline, with cylindrical warts: teleutosori similar to the uredosori, reddish-brown, wax-like; spores cylindrical, about 125μ long, 14–22μ wide, with orange-yellow contents.—On *Viguiera helianthoides*, near Tula, Oct. 6.

COLEOSPORIUM VIBURNI Arth.?—Uredo on *Viburnum*, near City of Mexico, Oct. 3.

COLEOSPORIUM IPOMŒÆ (Schw.) Burrill.—On *Ipomœa*, near City of Mexico, Oct. 7.

Pucciniosira Brickelliæ Diet. & Holw., n. sp.—On the stems and pedicels, forming irregular, mostly curved swellings; pseudoperidia shortly cylindrical, partly sunken, with margins irregularly toothed, cells verrucose, easily separating, yellow-white: teleutospores 2-celled, formed in long chains, separated by short sterile cells, elliptical, 28–35 by 18–24μ, at first not constricted,

finally separating into 2 cells; membrane hyaline, smooth.—On *Brickellia*, Rio Hondo, near City of Mexico, Oct. 4.

RAVENELIA APPENDICULATA Lagerh. & Diet.—On *Phyllanthus Galeottianus*, Guadalajara, Oct. 12.

Ravenelia expansa Diet. & Holw., n. sp.—Sori on both sides of the leaves, on large yellow spots, breaking through between the cuticle and epidermal cells: uredosori small, ochreous, containing numerous club-shaped brown paraphyses; spores elliptical or globose, 17–20 by 15–17μ, yellow-brown, with short spines: teleutosori irregular in outline, large, black-brown; heads hemispherical, 65–95μ in diameter, smooth, chestnut-brown, 5 to 6 spores in cross-section; spores cuneiform, 1-celled, 14–18μ broad, apex strongly thickened (about 7μ); cysts pear-shaped, only under the margin of the peripheral spores.—On *Acacia Tequilana* Wats., Guadalajara, Oct. 13.

Ravenelia Brongniartiæ Diet. & Holw., n. sp.—Sori breaking forth from beneath the epidermis: uredosori single or clustered, on both sides of the leaves, cinnamon-brown; spots large yellow, about 5^{mm} in diameter, spores ovate to globose, 23–30 by 18–25μ, with short spines and numerous germ-pores; paraphyses none: teleutosori not on spots, black; heads hemispherical, 85–115μ in diameter, with 5–6 spores in cross-section, dark chestnut-brown, thickly covered on the upper side with large warts; on the margins scattering large dark-brown blunt processes; inner spores of the head 2-celled, 16–21μ; cysts united into a coniform body, narrowed into the compound pedicel.—On *Brongniartia*, Cuernavaca, Sept. 23.

Ravenelia lævis Diet. & Holw., n. sp.—Sori on yellow spots about 1^{mm} in diameter, scattered or confluent in round groups, on both sides of the leaves: uredosori chestnut-brown; spores globose or ovate, 21–26 by 20–23μ, dark-brown, with short spines and numerous (12–15) germ-pores; paraphyses numerous, brown, clavate, stout: teleutosori black; heads irregularly rounded, hemispherical, 90–125μ in diameter, opaque, brown, smooth, with mostly 5–6 spores in each direction; inner spores with transverse septa, 20–26μ; cysts flat, on the underside of the

heads; pedicels compound.—On *Indigofera*, Esclava, near City of Mexico, Oct. 3; Guadalajara, Oct. 11.

Easily distinguished from *R. Indigoferae* Tranzschel by the upper side of the heads being smooth; but differs from *R. epiphylla* (Schw.) (*R. glanduliformis* B. & C.) only in the uredospores.

RAVENELIA EPIPHYLLA (Schw.) Farlow & Seymour.—On *Brongniartia podalymoides*, Guadalajara, Oct. 12.

Æcidium Bouvardiæ Diet. & Holw., n. sp.—Pseudoperidia on the underside of the leaves, on large (up to 1.5^{cm}) yellow or brownish spots, rather crowded, shortly cylindrical, orange-red when fresh, soon turning white; edges either erect or recurved, irregularly toothed; spores elliptical or almost globose, 18–25 by 15–20μ, finely verrucose.—On *Bouvardia triphylla*, Rio Hondo, near City of Mexico, Oct. 4.

Æcidium roseum Diet. & Holw., n. sp.—Spots bright rose-red or purple-red, often with a yellow center; pseudoperidia hypophyllous, in round or irregular groups, with recurved irregularly toothed edges; spores almost globose, or oblong, 25–33 by 23–26μ, with a thick, distinctly verrucose membrane, and orange-yellow contents, apex strongly thickened (5–8μ).—On *Eupatorium*, Esclava, near City of Mexico, Oct. 4.

Æcidium Mexicanum Diet. & Holw., n. sp.—Spots dry, circular, 3–6^{mm} in diameter, mostly with a yellowish-red margin; pseudoperidia on the edge of the spots, small, 0.25–0.30^{mm}, shortly cylindrical, yellowish-red, with erect, finely toothed white edges; spores mostly globose-polygonal, or elliptical, orange-yellow, with a hyaline, firm, often irregularly thickened finely verrucose membrane, 22–31 by 20–24μ.—On *Cissus*, near City of Mexico.

Distinguished from *Æ. Cissi* Wint. by its much larger spores.

Æcidium Montanoæ Diet. & Holw., n. sp.—Pseudoperidia upon swellings on the pedicels and young branches, causing considerable distortion, crowded, alveolate, with irregular deeply toothed edges; cells 40–60μ long; spores polygonal, almost globose, or irregularly ovate, 20–30 by 17–23μ, with a thin, hyaline, verrucose membrane.—On *Montanoa*, near City of Mexico, Oct. 1.

Æcidium Mirabilis Diet. & Holw., n. sp.— Pseudoperidia on the under side of large yellow circular or irregular spots, which sometimes have a blister-like elevation, at first cylindrical with finely toothed edges, later irregularly torn to the base; spores ovate or oblong, rarely globose, 20–30 by 14–22μ, with a thin slightly verrucose membrane.— On *Mirabilis*, Rio Hondo, near City of Mexico, Oct. 4.

Uredo pallida Diet. & Holw., n. sp.— Spots yellow or sometimes lacking; sori mostly epiphyllous, oblong or sublinear, scattered or confluent, yellowish-white when dry, surrounded by the ruptured epidermis; spores ovate to pyriform, 20–26 by 13–18μ, with hyaline shortly verrucose epispore.— On *Tripsacum dactyloides*, near City of Mexico, Oct. 1.

PODOSORDARIA Ellis & Holw., n. gen.— Perithecia united in a stipitate stroma. Asci and sporidia as in *Sordaria*.

Podosordaria Mexicana Ellis & Holw., n. sp.—Stroma with the short stipe irregularly obconical, 1–1.5^{mm} across, slightly mammillate above from the projecting apices of the perithecia, of carnose texture and of a light liver color: perithecia 3–10 in a stroma, ovate, globose, 400–500μ in diameter, with black papilliform ostiola: asci cylindrical, obscurely paraphysate, short-stipitate, 8-spored, 115–150 by 15–20μ: sporidia uniseriate, or biseriate above, elliptical, subhyaline at first, becoming nearly black and opaque, 25–34 by 12–14μ.— On cow dung, Cuernavaca, Sept. 23.

HYPOCREA FIBULA De Not.— On log, Cuernavaca, Sept. (Det. by Ellis.)

PARODIELLA PERISPOROIDES (B. & C.) Speg.— On *Zornia*, near City of Mexico, Oct. 1.

HOMOSTEGIA PARRYI (Farlow).— On *Agave*, Guadalajara, Oct. 12. (Det. by Ellis.)

PHYSALOSPORA ARALIÆ Pat.— On some araliaceous tree, Cuernavaca, Sept.

Perithecia hemispherical and sporidia smaller, but judging from the description it can hardly be separated. (Det. by Ellis.)

Bulgaria Mexicana Ellis & Holw., n. sp.—Obconic, stipitate,

$2.5-3.5^{cm}$ across, carnose-gelatinous, becoming hard and rigid when dry, with the margin involute and much wrinkled, glabrous, olive-black: hymenium reddish-brown, cracking and showing the white substance of the ascoma: stipe central, short, stout, wrinkled (when dry): asci cylindrical, stipitate, 8-spored, 250–270 by 15μ: paraphyses filiform, slightly thickened above and brownish: sporidia uniseriate allantoid, rounded at the ends, slightly curved, mostly with a large vacuole in the center, subhyaline, 25–34 by $8-10\mu$.— Cuernavaca, Sept.

Has the general appearance of *B. spongiosa* Pk., but with very different sporidia.

DECORAH, IOWA.

CONTRIBUTION TO THE THEORY OF THE MOVEMENTS OF DIATOMS.

W. M. KOZLOWSKI.

THERE are, as is known, two principal hypotheses to explain the enigmatical movements of the cells of Diatomaceæ. The one advanced by Ch. Nägeli seeks their cause in the osmotic currents between the cell and the surrounding water; the other, framed by Max Schulze, supposes that these movements are simply the creeping of the diatoms upon the surface of the object- or cover-glasses, performed by means of a protoplasmic pseudopodium issuing through a slit of the cell membrane. The view of Pfitzer, according to which the cell membrane of these algæ is composed of two distinct halves, one of them being adjusted to the other as a cover upon a box, seemed to give support to Schulze's explanation, and some observers have held that the movement can only take place when the cell is in contact with the glass and in a definite position with relation to it, and that, if that position be changed by shaking the glass with a needle, the movement will cease. Pfitzer himself believes that what is called the rhaphe of many Diatomaceæ is nothing but a slit through which the protoplasmic pseudopodium protrudes. No one has yet been so fortunate as to see the protoplasm passing out through this slit.

To these two old antagonistic hypotheses, each of which has found many apologists and opponents, Otto Müller recently added a new one.[1] After having studied the structure of the cell by means of thin sections,[2] he comes to the conclusion that the rhaphe is instrumental in transferring protoplasmic currents to the outside of the cell, and acts as a "propeller," by giving to these currents a screw like direction.

[1] *Die Ortsbewegungen der Bacillariaceen.* Berichte d. Deutsch. Bot. Gesell. 14: 1896.

[2] *Die Durchbrechungen der Zellwände, etc., ibid.*, 7: 177. 1889.

These views are opposed (rightly, it seems to me) by Lauterborn,[3] who affirms that such an arrangement as supposed by O. Müller could not impart motion to the cell.

I cannot go into the details of all the observations quoted *pro* and *contra* for each of these hypotheses, but if I can trust in my own observations, I am obliged to sustain the theory of osmotic currents. I have been very often in position to observe the movements of these organisms, either incidentally or with purpose, and I have never met with facts which could be advanced against the osmotic hypothesis.

These observations give me the conviction:

1. That the objection that movements are possible only in a definite position of the cell with respect to the glass (which is considered as the substratum) rests upon inexact observations. Many times I have seen cells of Diatomaceæ executing their progressive movements as well in the frontal as in the lateral position.[4] It is possible that various species behave differently in this line; but in very many of them, and especially in those symmetrical Naviculaceæ and Nitzschieæ, the position of the cell does not influence the movement. It is stopped sometimes by the sudden change of position in consequence of a shock, which may be easily explained by the rigor which generally follows such treatment of the protoplasm.

2. Nor do I think the affirmation exact that contact with the glass is essential to movements.[5] So far as my own experience reaches, I observed on the contrary that such contact is an impediment to the movement and perhaps is the cause of the transformation of free swimming (gliding) of the cell into creeping. The impediment is found partly in the friction, partly in the sticking of the mucus surrounding the cell membrane to the

[3] *Zur Frage nach der Ortsbewegungen der Diatomaceen.* Ber. d. D. Bot. Ges. 12: 73. 1894.

[4] This observation is in accord with that of O. Müller, that the position towards the substratum does not influence the movement in *Pinnularia, Stauroneis Phoenicentron*, and *Nitzschia sigmoidea*.

[5] The same objection is stated by O. Müller, who observed the movements of the algæ in a drop of water suspended from a cover glass.

glass. It happens sometimes that the movement of translation is stopped for a while, after which the cell seems to make efforts to pluck itself away from the substratum and then runs forward, only to stop again after a little course and to repeat this play again.

And sometimes the cell, stopped in its movement, goes away from the substratum, being retained only by a small gelatinous cushion sticking to the cover glass, and performs small oscillations in that position. It makes the impression that the osmotic currents between the cell and the surrounding water are too weak to overcome the resistance of the adhesive mucus, and cause these oscillations.

Pfitzer, in his interesting study upon Bacillariaceæ in Schenck's *Handbuch der Botanik*, has raised a theoretical objection against the osmotic theory of movements. He suggests that the low velocity of the osmotic current cannot furnish sufficient force to account for the forward motion of the cell. The objection really is based upon a misunderstanding; for in all movements produced by flowing out of liquid from a vessel (or flowing into it) the cause of the movement does not lie in the velocity of the current, but exclusively in the change in the position at the center of inertia, and it is equally true whether the liquid flows out through macroscopical or molecular openings.

We then have no reason to put aside the endosmotic hypothesis of movements, inasmuch as no observation has proved the existence of plasmatic pseudopodia or other organs for creeping;[6] and, moreover, that hypothesis gives us the basis for the explanation of some peculiarities of these very enigmatic movements.

The movements of the Diatomaceæ were very precisely described by the late E. Borščow,[7] who discerns three types: first, sliding; second, creeping; third, the above described intermittent movement or leaping.

The most characteristic are the sliding or swimming move-

[6] O. Müller states in concordance with many further observations that what were considered as flagella are simply alien fungi. "The pseudocilia," says he, "are Abgüsse der Riefenkammern." *Ibid.* 14: 58, 59. 1896.

[7] Die Süsswasserbacillariaceen des südwestlichen Russland. Kief. 1875.

ments, showing a wonderful periodicity. The cell (usually a symmetric one such as Nitschia or Navicula) begins to swim with a gradually increasing velocity in some definite direction; then the velocity diminishes, and finally the cell stops its movement to recommence it with the same rhythm in the opposite direction, or in a line differing by some small angle from its first path.

These movements have thus all the characteristics of pendulum movements, *i. e.*, the periodic change of the direction (or of the sine, to speak mathematically), and of the velocity, going through the zero (the stopping of the cell) and attaining its maximum at the middle of the path. These movements, as known, have their origin in such a combination of forces, that the point towards which the acceleration is directed is placed at the middle between the two termini of the movement.

Some observations suggested to me the supposition that this point, in microscopical observation, is determined by the apex of the cone of rays reflected from the mirror to the opening on the stage.

If we consider the osmotic hypothesis as true, to which, as we have seen, there is no serious objection, there are two functions, each of which is most constant in the cell, which may be the source of those products that are the ground of osmotic currents between the cell and its surrounding. These are *respiration*, which is continuous and the products of which are perpetually exosmosed by the cell, and *assimilation*, which takes place only in light, and which produces most probably some kind of sugar (as is known, the Diatomaceæ do not contain starch), that is, a substance of high osmotic activity and producing osmotic attractions to the interior of the cell.[8]

Many times I have observed that the movements of the Diatomaceæ are very energetic when freshly collected and brought under the microscope in the fresh, cold water, espe-

[8] The osmotic tension in the cells of *Pinnularia major* and *Surirella biseriata* as measured by plasmolysis is no less than 4 or 5 atmospheres (*Cf.* O. Müller, *ibid* 7:169. 1889). That shows how strong must be the predominance of endosmosis over exosmosis.

cially when it is spring water. Gradually, during the time of the observation, the movements became less active, and at the end—if the drop is not changed—they cease altogether. That is quite explicable by the contained gases in fresh and cold water, which are gradually exhausted or evaporated, in consequence of the warming of the drop. This observation gives equal support to both of the functions proposed as causal.

But there are some other observations which seem decisive in favor of the assimilation being the real cause of movements. These are:

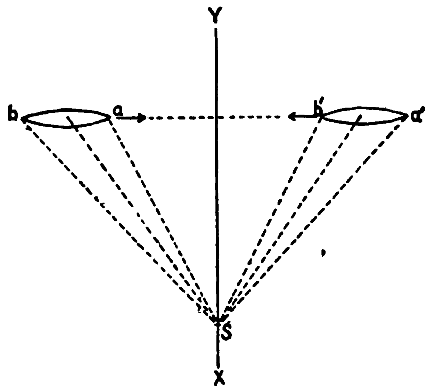
1. *The dependence of movements upon light.*—It is impossible to make direct observation in darkness, as in these conditions we could see nothing; but the following experiment speaks for the above stated dependence: If, while observing a cell in movement, we suddenly cover the mirror so as to intercept all the rays of light, upon uncovering of the mirror after some minutes we generally find the cell at rest not far from the place where it was seen before the light was cut off. It does not start forward at the moment when light is again admitted, but for some time seems to be in a state of rigor and then gradually begins to move. That little experiment was repeated many times, and always with success.

2. *The dependence of the movement upon the color of the light.*—I used for this purpose the light transmitted through solutions of ammoniated copper oxide and of bichromate of potassium, both 1^{cm} thick. As shown by spectroscopic analysis the first allowed the more refrangible rays from the middle of green to pass; the second transmitted the opposite part of the spectrum. The blue rays do not promote the motion; the red ones promote them very energetically. By means of such rays I succeeded in setting in movement some big cells of Pinnularia, Surirella, and others, quite immobile in the daylight.

3. *The dependence of movements upon the direction of light.*—If we remove slowly the slide carrying a diatom moving in the manner described, so as not to allow the cell to cross a plane passing through the apex of the light cone perpendicular to the

path of the cell, *i. e.*, so that the light should fall always ahead of the cell, we can arbitrarily prolong the movement in the same direction and hinder the cell from retracing its path.

These observations showing the dependence of movements upon light, their prevalence in the red light which, as known, is the most advantageous for assimilation, and the influence of the direction of incident light on that of the movements, give support to the supposition that assimilation is the real ground of movements.



That being stated, how shall we conceive the mechanism of these movements? Imagine a diatom cell to be at a certain distance from the apex (*s*) of the light-cone, with one of its ends directed toward it (see figure).

The half directed towards the light (which we will name the anterior) will receive more light (because of the less inclosed direction of rays towards it) than the posterior half. Consequently assimilation will take place here with more energy, and in the same ratio the endosmotic current to the interior of the cell will be more energetic, since it is dependent on the quantity of elaborated products of assimilation. The result will be that the cell will be impelled towards the source as a canoe would be in whose bow a suction pump had been placed.

While the cell is approaching the apex of the light-cone, the difference of insolation of both halves of the cell is gradually lessened, and thus the acceleration in the given direction, depending upon this difference, grows more and more near zero, which value it reaches at the moment when the center of the cell corresponds to the plane (xy) passing through the apex of the light-cone perpendicular to the direction of the movement at the cell.

At this point its velocity attains its maximum because of the sum of all the foregoing accelerations.

After this plane is crossed the conditions are changed; the posterior end receives now more light than the anterior; the process of assimilation is going on there with more energy, and as the result the osmotic currents to the interior of the cell are strengthened. The direction of the acceleration (always being toward the center of light) is inverted as to the direction of the movement, which it now impedes. The velocity is thus gradually lessened, and after having reached zero is changed, too. The cell now runs back, repeating the same type of movement as it did when going forward, and those oscillations are repeated many times.

They would go on in the same plane, were they not disturbed by some occasional hindrance, such as the currents produced in water by heat, contact with other bodies, and so on, which effect a deviation from the primary direction and a return at some angle to it.

If we take into consideration the very low velocity of the diatom cells and their small mass, the slight difference in the quantity of light received by the two halves of the cell will not appear insufficient to account for its movement.

It is not impossible that other kinds of movement could be reduced to this gliding type and be explained in the same way. The above described observations make it not improbable that these other kinds can be deduced from the first one by the action of some hindrance, such as the sticking of the mucus surrounding the outside of the cell to the glass, or the friction when the cell is approaching one of the glasses.

The explanation here proposed, making the periodicity of the movements dependent upon the artificial disposition of the light in the microscope, which is hardly to be found in nature, does not indeed exclude motion under natural conditions. For the matter is not essentially changed by the fact that the rays, instead of being divergent, are parallel, and that their direction towards the cell is unchanged by its movement, as is the

case in daylight. The result will be a movement towards light, or as it is generally termed positive phototaxis. That such a phenomenon really exists among the Diatomaceæ everyone knows who has observed the pools containing these algæ in a summer day. And this kind of phototaxis, which the Diatomaceæ have in common with the great part of unicellular organisms containing chlorophyll, is without doubt of use to them, for moving towards the light places the cells in the most advantageous conditions for assimilation.

CHICAGO.

BRIEFER ARTICLES.

REVISION OF LILÆOPSIS.

Crantzia Nutt. Gen. 1: 178. 1818; not of Scopoli (1777) and others.

Lilæopsis Greene, Pittonia 2: 192. 1891.

The genus long known as Crantzia of Nuttall, and recently renamed Lilæopsis by Greene under the rule of homonyms, has such a characteristic habit that all of its forms have been merged into a single species, although earlier botanists proposed several. An examination of abundant material from different regions reveals several distinct types with well defined geographical areas. The following North American species seem to be worthy of recognition.

* ***Fruit with lateral ribs prominently corky thickened, much more conspicuous than the dorsal ones which are not at all corky.***

1. LILÆOPSIS LINEATA (Michx.) Greene, Pittonia 2: 192. 1891.

Hydrocotyle lineata Michx. Fl. Bor. Amer. 1: 162. 1803.

Crantzia lineata Nutt. Gen. 1: 178. 1818.

The Kew Index refers *Hydrocotyle Chinensis* L. to this species, which, if true, would require the use of the specific name *Chinensis*.

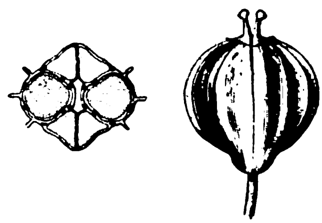


FIG. 1.

Fruit and fruit section of *L. lineata*

Leaves short, 2 to 5^{cm} long, linear spatulate: peduncles longer than the leaves, 3 to 7^{cm} long.—Along the Atlantic and Gulf coasts from Massachusetts to Mississippi.

Specimens examined.—MASSACHUSETTS, Wareham (*G. G. Kennedy*, July 8, 1890): CONNECTICUT, New Haven (*Dana*; also *C. Wright*, 1884): RHODE ISLAND, Providence (*S. T. Olney*, July 22, 1845): NEW JERSEY (*T. Nuttall*, with no locality): VIRGINIA, Colonial Beach (*F. V. Coville*, July 6, 1890): FLORIDA (*Dr. Chapman*, with no locality); shore of St. John's river near Jacksonville (*A. H. Curtiss*, 993; 4341, May 9, 1893; and 4915, June 19, 1894; also *Dr. J. Torrey*); Tampa (*Dr. A. P. Garber*, May 1876.)

2. **Lilæopsis occidentalis,** sp. nov.

Leaves elongated linear, narrowing above, 3 to 18^{cm} long: peduncles much shorter than the leaves, 2 to 4^{cm} long.—Coast region of Oregon, Washington, and Vancouver island.

Specimens examined.—OREGON, salt marshes of Tillamook bay (*Thos. Howell,* July 11, 1882; *L. F. Henderson* 403, July 14, 1882); Light House point, four miles above Astoria (*Thos. Meehan,* August 1883); wet places on coast of Yaquina bay (*Elihu Hall* 205, September, 1871): WASHINGTON, on springy, gravelly shore of Lake Washington, King county (*W. N. Suksdorf* 972, August 4, 1890); Seattle (*C. V. Piper* 642, June 20, 1889); Puget sound (*Wilkes Expedition*): VANCOUVER ISLAND, near Como (*James Macoun,* July 1, 1893); Chase river (*James Macoun,* June 3, 1887).

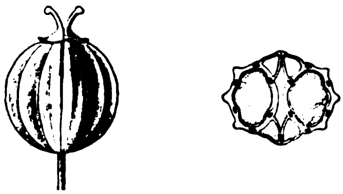


FIG. 2.

Fruit and fruit section of *L. occidentalis.*

This species was referred by Dr. Torrey, in the *Report of the Wilkes Expedition* **17**: 313, to *Crantzia attenuata,* a species known only from eastern South America. From the meager description of the latter species, as well as the great geographical separation, we have no hesitation in keeping the two forms apart.

***Fruit with all the ribs corky thickened, the laterals more prominent: peduncles much shorter than the leaves.*

3. **Lilæopsis Carolinensis,** sp. nov.

Leaves very narrow and elongated below, broadening into a spatulate or oblong blade, 5 to 25^{cm} long by 4 to 15^{mm} wide: peduncles very short, 1 to 1.5^{cm} long: dorsal ribs sharply acute.—Eastern North Carolina (*G. McCarthy,* 1884).

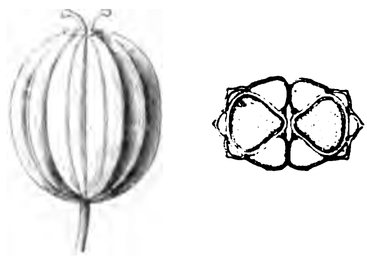


FIG. 3.

Fruit and fruit section of *L. Carolinensis.*

4. LILÆOPSIS SCHAFFNERIANA (Schlecht.) Coulter & Rose.

Crantzia Schaffneriana Schlecht. Linnæa **26**: 370. 1853.

Leaves when growing in drier places almost filiform and short (6^{cm} long), when growing in water elongated linear, 2.25 to 30^{cm} long: peduncles very short: fruit oblong, the dorsal ribs obtuse.—Southern Arizona and southward through Mexico to Chili.

Specimens examined.—ARIZONA, Santa Cruz valley near Tucson (*C. G. Pringle*, May 19, 1881); springs in Huachuca mountains (*J. G. Lemmon* 3, August, 1882): MEXICO, chiefly in the region of San Luis Potosi (*J. G. Schaffner* 1, 1876; also *C. C. Parry* and *Edward Palmer* 287, 1878): CHILI, southern part of Province Concepcion (*R. A. Philippi*).

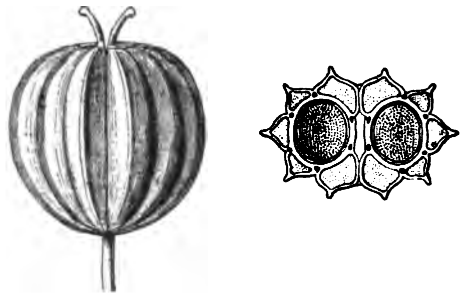


FIG. 4.

Fruit and fruit section of *L. Schaffneriana.*

The forms from the Australian region and from Brazil, which have been referred to *Crantzia lineata*, are probably two distinct species different from those described above. From the imperfect material examined and the meager descriptions it is evident, at least, that they cannot be *Lilæopsis lineata.*—JOHN M. COULTER, *University of Chicago*, and J. N. ROSE, *Washington, D. C.*

A NEGLECTED NORTH AMERICAN EUPHORBIA.

(WITH PLATE III)

IT is with considerable hesitation that the writer ventures to describe another species in this large and complicated genus, the specific limitations in which, so far as our American representatives are concerned, are so very imperfectly understood. The particular form in question, however, stands out so sharply from its near relatives that one seems entirely justified in treating it as a distinct species. The plant was noticed several years ago growing upon dry waste soil about Ithaca, N. Y. Not far distant were specimens of both *E. maculata* and *E. nutans*, from which it differed so greatly in appearance that a more careful study was made of it during each succeeding summer, the final result being that other characters were found to support this difference in general appearance, which are noted in the following description.

The history of the American species of the section ANISOPHYLLUM has been very much involved since the earliest times, principally because the early botanists did not understand the value of the fruit and seed characters used so much at present. The types of the older species are therefore exceptionally vague.

In 1753 Linnaeus[1] described under the name *E. maculata* the plant that goes under that name at present. The characters, "leaves pilose, spotted, calyx red," indicate this, as do also the comparisons made with the type material under the direction of Dr. Torrey.[2] Linnaeus, however, in the second edition of *Species Plantarum*, and in his subsequent works, confuses our new form with *E. maculata*, "dichotomous, branches patulate, leaves serrate, flowers axillary and solitary, fruit smooth." Willdenow's[3] *E. maculata* is for the most part *E. hirsuta* (fruit smooth, etc.), but "calyx red," on the other hand, refers rather to the *E. maculata* of *Sp. Pl.* ed. 1. Pursh[4] describes *E. maculata* as "erect-patulate, pilose, involucre of the florets white," which evidently refers to *E. hirsuta*. The name *maculata* is correctly applied by Torrey, Bigelow, Darlington, and Barton. *E. hirsuta* was first recognized and described by Torrey[5] as *E. hypericifolia* var. *hirsuta*, but for some reason since that time it has been entirely overlooked.

The *E. hypericifolia* of Linnaeus is very indefinite. Linnaeus gives its habitat as India, which Willdenow further modifies to West India. Many of the American authors have considered the United States form as identical with the Linnaean plant. Boissier and others hold that the West Indian form is entirely distinct from the northern plant called by Boissier[6] *E. Preslii* Guss., but should go under the older name *E. nutans* Lag. *E. thymifolia* was a name applied by Linnaeus to a probable Indian species, but later applied by Willdenow, Michaux, and Pursh to some one of the procumbent hairy species of the western states.

According to the present rules of priority, the form in question must receive Torrey's name and become *E. hirsuta* (Torrey). Our plant is found in most herbaria, named either *E. Preslii*, which it resembles in its fruit, or *E. maculata* and *E. humistrata*, which it resembles somewhat in general appearance.

The writer is indebted to Mr. Coville and Dr. Small for the use of additional material, thus making it possible to draw up the following detailed account of the species.

Euphorbia hirsuta (Torrey).

E. maculata L. Sp. Pl. ed. 2, 1762 (in part); Willd. Sp. Pl. 1799 (in part); Pursh Fl. Am. sept. 1814.

E. hypericifolia var. *hirsuta* Torr. Fl. North. and Middle States 331. 1826.

[1] Sp. Pl. ed. 1. 455. 1753.

[2] Fl. N. Y. State **2**: 176. 1843.

[3] Sp. Pl. ed. 2. 896. 1799.

[4] Fl. Amer. sept. **2**: 605. 1814.

[5] Fl. North. and Mid. States 331. 1826.

[6] DC. Prod. **15**: 23. 1865.

Decumbent, forming large mats: stems 10–25^{cm} long, dichotomously much branched, slender, zigzag, commonly rufescent on the upper side, more or less hirsute; leaves ovate-oblong (8–15^{mm} long), oblique at base, acutish, slightly sulcate, sharply serrulate nearly to the base, palmately 3–5-nerved, light-green above, somewhat paler beneath, clothed with scattered hairs; petioles slender, about 1^{mm} long; stipules inconspicuous, subulate, fimbriate: flowers clustered near the ends of the branches, peduncles longer than the petioles (1.5^{mm} long), slender: involucre funnelform (1^{mm} high), glabrous; glands cupulate, circular, dark-brown, on rather long pedicels; appendages small, only slightly exceeding the glands, crenate, white; involucral teeth equaling the gland, laciniæ few; crests in the throat of the involucre small, slightly lacerate: capsules medium (1.75^{mm} long by 2^{mm} wide), oval-oblong, glabrous, rounded at base, retuse at apex, angles very obtuse; styles deeply cleft: seeds of medium size (1.25^{mm} long), obovoid-oblong, rounded at apex, acutish at base, black but covered with a white coating, 4-angled, faces very slightly undulate or even; raphe conspicuous as a very dark line.

Dry, sandy, and gravelly soil, southern Canada, New York, and Pennsylvania.

Besides the central New York material collected by the writer, specimens have been examined as follows:

Ottawa, Ont. (*Macoun*, U. S. Herb.); Kingston, Ont. (*Fowler*, U. S. Herb.); Toronto, Ont. (*Weller*, Cornell Univ. Herb.); Danville, Quebec (*Berg*, Herb. Col. Coll.); Manitou Beach (*Britton*, Herb. Col. Coll.); Canandaigua Lake, N. Y. (*Britton*, Herb. Col. Coll.); Niagara county, N. Y. (*Townsend*, Herb. Cornell Univ.); Lake George, N. Y. (*Vasey*, Herb. Col. Coll.); Weehawken, N. J. (*Van Seckle*, U. S. Herb.); Lancaster county, Pa. (*Small*, Herb. Col. Coll.)

This species is abundant in central New York, growing preferably along railroad embankments, roadsides, and similar waste places. Although growing often in company with *E. maculata* and *E. nutans*, it is usually more abundant than either, and is conspicuous on account of its diffuse decumbent habit and light-green color. It becomes strictly erect when attacked by the æcidial stage of the fungus *Uromyces Euphorbiæ*, and occasionally when growing among other herbs.

The following synopsis will show the relation of *E. hirsuta* to some of the other species with which it has been confounded:

A. Seeds rufous (with a white coating), small (0.82–1.00^{mm} long), one angle acute, the others mostly obtuse: capsule small (1.25^{mm} long), ovate, rather acutely angled, glabrous or hairy: flowers in lateral clusters: stems prostrate (or erect in *E. glyptosperma*).

Seeds strongly furrowed, angles usually crenate: stems and capsule glabrous, the latter acutely angled: appendages white. *E. glyptosperma.*

Seeds lightly furrowed: stems and capsule hairy.

Leaves elliptical (12–14^{mm} long): seeds nearly without furrows, granulate: involucre cleft down one side. - *E. humifusa* Engelm.

Leaves oblong-linear (9^{mm} or less): seeds transversely furrowed, slightly cellular-papillose: involucre not cleft; appendages usually pink. *E. maculata* L.

B. Seeds black (with a white coating), larger (1.12–1.25^{mm} long): capsule larger (1.75–2.25^{mm} long), glabrous: flower clusters terminal: stems erect, ascending or decumbent.

Capsule ovate (2.25^{mm} long), rather sharply angled, rounded at summit: seeds oval, very obtusely angled (1.77^{mm} wide), covered with short and sharp irregular ridges: stems erect or ascending, stout, glabrous or nearly so (25–40^{cm} long): leaves 20–35^{mm} long, dark-green, usually with a central red spot - - - - - *E. nutans* Lag.

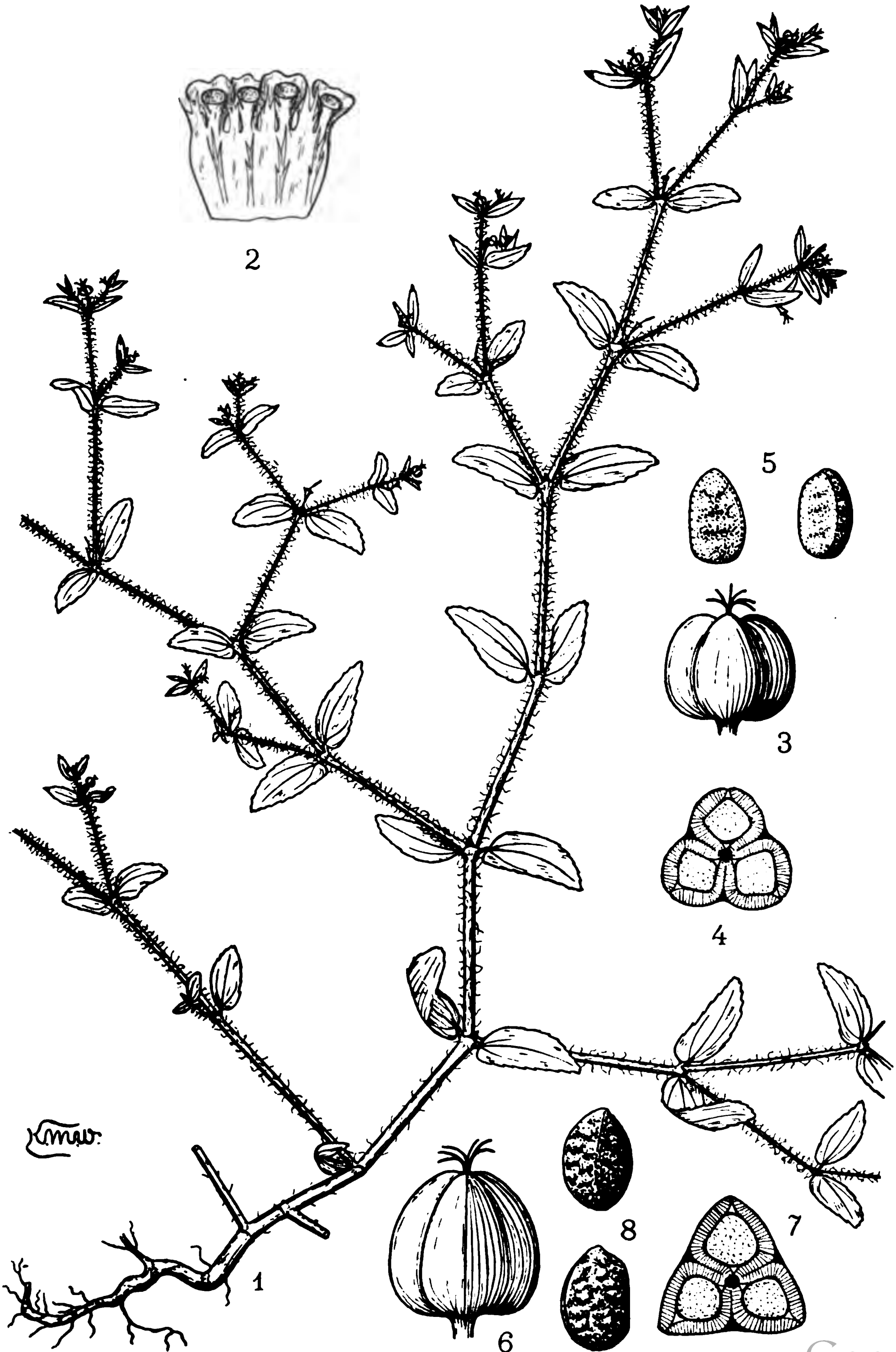
Capsule very broadly oblong or broadly oval, smaller (1.75^{mm} long, 2^{mm} wide), retuse, very obtusely angled: seeds oblong, more acutely angled (0.67–0.70^{mm} wide) and with a few shallow furrows or nearly even: stems slender, diffusely much branched, decumbent, hirsute: leaves smaller (8–18^{mm} long), light-green, rarely with a central red spot. *E. hirsuta* (Torr.)

— KARL MCKAY WIEGAND, *Cornell University.*

EXPLANATION OF PLATE III.—Fig. 1, *E. hirsuta*, plant natural size. Fig. 2, involucre. Fig. 3, capsule. Fig. 4, same in cross section, Fig. 5, seeds. Figs. 6 and 7, capsule of *E. nutans*. Fig. 8, seeds of the same.

ŒDEMA IN ROOTS OF SALIX NIGRA.

MANY species of Salix when growing along streams or ponds will form masses of roots differing much from those growing in the soil. The roots arise, as a rule, from near the base of the trunk. They are long and straight and have but few branches. Their structure is somewhat modified because of their unusual environment. Around the central cylinder is a loose cortex of parenchymatous cells supplied with



EUPHORBIA HIRSUTA (Torr.) Wiegand.

numerous intercellular spaces. In roots of this kind, particularly of ash and Gleditschia, one oftentimes finds water lenticels. While looking over a mass of such roots of *Salix nigra* for lenticels I found some white structures which were taken for lenticels. At points from 5 to 10^{mm} from the root tips, small white protuberances occurred, sometimes as many as four on one root tip. The root at this point has a cortex particularly well supplied with intercellular spaces. Sections made through the white cushions presented a condition reproduced in the accompanying figures. At *a* the cortex is seen in its normal condition. *Fig. 1b* shows some of the inner cells radially elongated, and at one point the elongation has been sufficient to burst the epidermis. In *fig. 2* this condition is still more marked. Some of the cells have increased to many times their normal size, leaving large spaces between them. It is evident that these structures have nothing in common with lenticels, but partake of the nature of œdemata, resembling those described by Atkinson for the tomato and apple.[1]

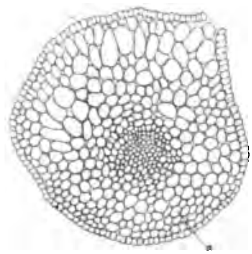


FIG. 1. Transection through root of *Salix nigra* 5^{mm} from the tip; *a*, normal cortex; *b*, elongated cells.

In those cases the œdema was ascribed to a high turgor brought about by too great root absorption and lowered transpiration. The willow, from which the affected roots were taken, stands at the edge of a pond and has but few of its roots in the water. There had been a week of very warm weather, followed by almost freezing temperature. The leaves had all fallen some two weeks before. The roots were collected during the cold weather, and when examined the œdemata appeared to have been but recently formed. In seeking for an explanation for these œdemata I am inclined to ascribe them to causes similar to those given for the apple, brought about by different conditions. During the week of warm weather, with a soil tem-

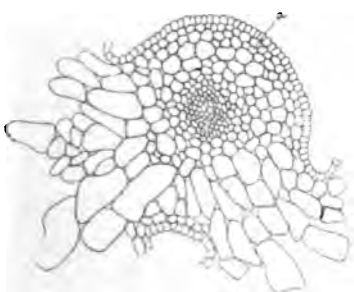


FIG. 2. Transection through advanced stage of a cushion 5^{mm} from the tip.

[1] Cornell University Exp. St. Bull. no. 53, May 1893, and no. 61, Dec. 1893.

perature rather high, the roots probably absorbed a certain quantity of water which was unable to escape in proportionate amounts, because of the absence of transpiring leaves. In this way a large amount of water might have accumulated in the root system and trunk. Of the roots, those growing in the water have the thinnest walls, both in the epidermis and cortex, and when the tension became too great, elongation of the subepidermal cells took place. All roots in the water had cushions more or less developed, while the soil roots failed to show them. No indications of any œdematous structures were to be found in the branches.— HERMANN VON SCHRENK, *Shaw School of Botany, St. Louis.*

ON THE PRESENCE AND LOCALIZATION IN CERTAIN POMACEOUS SEEDS OF THE PRINCIPLES PRODUCING CYANHYDRIC ACID.

It is well known that certain of the Amygdalaceæ contain two principles which in their reaction upon each other in the presence of water produce cyanhydric acid. These two principles are *emulsin*, a ferment, and *amygdalin*, a glucoside. The amygdalin and emulsin occur in different cells in the plants which contain them, so that laceration of tissues is necessary for production of cyanhydric acid. It is not the Amygdalaceæ alone that contain the principles that generate cyanhydric acid, but they are to be found in many plants of different families.

Kobert,[1] who gives a very complete enumeration of such plants, mentions the seeds of *Malus communis* as containing emulsin and amygdalin. He does not insist upon the presence of these substances in apple seeds, and does not mention any other of the Pomaceæ. It seemed well, therefore, to extend the investigation throughout the group. To determine the presence of the generative principles of cyanhydric acid in pomaceous seeds I followed the classical experiments for the determination of this acid, and the methods employed by M. L. Guignard in his earlier investigations of this subject.

1. The seeds are crushed in a glass mortar in a small amount of water, and tested as to a development of the odor of bitter almonds.

2. The product is diluted in a larger amount of water and distilled in a glass retort. The first portions of the liquid passing over in dis-

[1] Lehrbuch der Intoxicationen 510.

tillation are collected, and tested with silver cyanide, isopurpurate (hot potassium and picric acid), and ammonium sulfocyanide. The action of the isopurpurate is especially characteristic.

3. If these tests give negative results, it may be due to the absence of one of the generative principles. It is well, therefore, to repeat the experiments upon the seeds, crushing them in the presence of amygdalin and emulsin successively.

As a result of such experiments I am able to make the following statements :

1. Amygdalin and emulsin exist together in the seeds of *Malus communis*, *Cydonia vulgaris*, *C. Japonica*, *Sorbus Aucuparia*, and *S. Aria*.

2. They do not occur together in the seeds of *Pirus communis*, *Cratægus oxyacantha*, *C. Azarolus*, and *Mespilus Germanica*.

The localization of emulsin and amygdalin in pomaceous seeds is difficult on account of the very small amounts in which they occur.

Emulsin.—This substance can be localized in these seeds only by the reagent of Millon. The other tests for proteids and ferments give only negative or doubtful results. The reagent acts very slowly. Place upon a slide a drop of Millon's reagent diluted to one-fourth or one-fifth by water acidulated with nitric acid. In this mount the sections to be tested, and heat so that for at least seven or eight minutes nearly a boiling temperature may be obtained. The sections become rose-colored, at first exceedingly pale, but gradually deepening. When the color is quite uniform throughout, and the temperature is nearly that of boiling, the preparation is cooled and examined. The cells containing the emulsin are stained brown, all other cells being pale rose color. In this manner I have demonstrated that the emulsin occurs in numerous cells scattered through the parenchyma of the cotyledons, and especially in the vicinity of woody bundles, whose endodermis likewise contains it. It is entirely lacking, however, in the external palisade cells. The hypocotyl, plumule, and root do not contain it, a fact that can be further demonstrated by detaching these regions and crushing them in a small quantity of amygdalin, when there is not developed the odor of almonds.

Amygdalin.—Precise localization of this glucoside is impossible on account of its very minute quantity, which baffles the most delicate tests. It may be stated, however, (1) that this substance occurs in the cotyledons, since they contain the emulsin and by crushing develop

cyanhydric acid; (2) that it exists in the hypocotyl, plumule, and root, since when these organs are detached from the cotyledons and crushed in a fresh solution of emulsin the odor of bitter almonds is developed.

Finally, I have proved that germination does not change the localization of these two substances. The emulsin, in particular, does not change its position in the seedling, or only after having undergone certain changes which modify its nature and properties.—M. L. LUTZ, *Paris*.

SYNONYMY OF MUCILAGO SPONGIOSA (Leys.).

THE earliest reference to any form of Myxomycetes appears in a citation by Haller from "Phil. Bonanni, Recreationes mentis & oculis, Rom. anno 1684." Its synonymy may be presented in the order of time as follows:

1. *Mucilago filamentosa ramosa* Bonanni, Recreationes 1684.
2. *Mucilago crustacea alba* Micheli, Nov. Pl. Gen. 1729; Battarra, Fung. Hist. 1755.
3. *Mucilago crustacea alba*, α. β. γ. Haller, Eu. Stirp. Helv. 1742.
4. *Mucor crustaceus, spongiam simulans, cortice in pulverem fatiscente* Gleditsch, Meth. Fung. 1753.
5. *Mucilago*. Adanson, Fam. des Pl. 1763.
6. *Mucilago alba, crustacea & filamentosa*, α. β. γ. Haller, Hist. Stirp. Helv. 1768.
7. *Byssus bombycina* Retzius, Act. Holm. 1769.
8. *Byssus floccosa* Schreber, Spic. Lips. 1771.
9. *Mucor spongiosus* Leysser, Fl. Hal. 1783.
10. *Mucilago crustacea* Schrank, Bay. Fl. 1789.
11. *Reticularia alba* Bulliard, Champ. 1791.
12. *Spumaria mucilago* Gmelin, Syst. Veg. 1791.
13. *Reticularia ovata*, var. Withering, Bot. Arr. 1792.
14. *Spumaria cornuta* Schumacher, Eu. Pl. 1803.
15. *Spumaria alba* De Candolle, Fl. Fr. 1805.

In no. 6, as in no. 3, Haller's species is much more extensive than in the synonymy elsewhere; it includes three of Micheli's species which he considers all forms or varieties of one. The second form, "β. *Mucilago alba, ramosa, radices arborum simulans* Micheli, p. 216, *t. 96, f. 3*" is considered by Fries to be a representation of the plasmodium of some species; it is under this form the citation from

Bonanni occurs. What is very singular, however, is that Rostafinski refers this extract to Bonamy, Fl. Nannetensis, 1782.

The synonymy shows clearly that after the Linnean date of 1753 Mucilago is used generically by Battarra, Adanson, Haller, and Schrank. This is certainly sufficient to establish and maintain its use as the proper generic term.

. In seeking to establish the specific name we reach the following result. *Byssus bombycina* of Retzius is admitted by Rostafinski evidently on the authority of Schrank, Bay. Flora 638. Retzius, Bot. Obs. fasc. 1 : 34, states distinctly that *Byssus bombycina* is *Byssus floccosa* of Schreber. Persoon, Synopsis 696, accepts them as identical and refers them to his genus Dematium. Fries, S. M. 3 : 379, considers them merely hyphæ. In fact, Schrank's *Mucilago crustacea* at most can apply only to forms β and γ of Haller, which are outside the species. It is strange Rostafinski did not quote this name as a synonym.

The next name in order of time is *Mucor spongiosus* Leysser, Flora Halensis, 2 ed. 1783. The reference is to the page and figure of Micheli, which is universally accepted as representing the species, and the description also accords perfectly with it. This citation escaped Rostafinski altogether, and the reason for it is very curious. Rostafinski's synonymy in general is copied bodily from Fries S. M., and from its index. *Mucor spongiosus* does indeed occur in the index, but a slip of pen or of type refers it to Leers instead of Leys., and of course it could not be verified.

So far, then, as we have been able to trace the synonymy the correct name for the *Reticularia alba* of Bulliard, *Spumaria mucilago* of Persoon, and *Spumaria alba* of De Candolle, is *Mucilago spongiosa* (Leys.).—A. P. MORGAN, *Preston, O.*

OPEN LETTERS.

NEW SPECIES.

To the Editors of the Botanical Gazette :—Your editorial on "New Species," in the April number, emphasizes a line of thought that kept me for many years from publishing any of the undescribed forms of fungi that came to my notice. It seemed presumptuous for an isolated worker, having access to but few books or authentic specimens, to attempt to describe new species in groups where the literature and synonymy were in such confusion that the best equipped mycologist could seemingly only flounder in the mire.

Farther reflection, and the problems encountered in attempting the study of our southern mycological flora, in which so large a proportion of the forms observed are evidently undescribed, have led me to change my views. You say that in former days "classification was confessedly artificial, the purpose being little more than a convenient cataloguing of forms." Very good, and I would add that in these lower groups the condition you describe still exists, and until we get a fairly complete "convenient catalogue" I see no alternative but to continue making "new species" of such discovered forms as seem to be undescribed. No one appreciates more fully than the makers of these species that their work is only tentative; but how are we to base a classification "upon genetic relationships as indicated by a careful study of morphology" until we at least know of the existence of the forms that are to be classified; and how is this knowledge to be obtained unless each observer makes a permanent record of the new forms he discovers?

I have come to quite agree with the views of a brilliant young zoologist and botanist, one of the few who in recent years have made a reputation in both fields, when he expressed the thought that it was not the occasional renaming of old species and the consequent multiplication of synonyms that produced serious confusion in nomenclature. When such new names are accompanied by sufficient and carefully drawn descriptions they do but little harm. It is the publishing of names with slovenly and unrecognizable descriptions, and the carelessly erroneous reference of new forms to old species that have caused an almost hopeless condition of chaos in some of these lower groups.

When a reasonably complete number of the forms that actually occur in nature of parasitic fungi and other low plants have been collected, named,

described and catalogued, then and not till then will it be possible to trace their relationships and to express their true affinities by means of a thoroughly well considered natural classification. The student who concerns himself alone with the higher plants cannot appreciate the difficulties that still remain to be surmounted before this highly desirable end can be attained, or there would be fewer to criticise the efforts of those who are doing what is well understood to be preliminary work, but work that is just as essential to botanical progress as that which is to follow. Those of us who are attempting to work with these perplexing and almost innumerable forms, and are therefore in a position to judge of the immensity of this field and the utterly inadequate study it has so far received, are compelled to smile when we hear some young anatomist or physiologist gravely assert that "work in systematic botany is practically finished in this country." It seems to be the fashion in some quarters to decry all field workers as "mere collectors;" and I have even seen the assertion that the time has passed when amateurs, or those who were not able to devote their whole time to botanical study, could hope to do any work that would be of real service to botanical progress. I cannot help thinking that these are narrow views, and that their publication tends to work harm by discouraging those who feel attracted by botanical studies. The busy man, whose love of nature compels him to spend his Sundays and holidays in the woods and fields, often gains that intimate knowledge of plants as they really are, and of their relationship to their environment that is sometimes sadly lacking in the professional botanist whose horizon is bounded by his laboratory walls. The true scientific spirit is that which utilizes every scrap of knowledge, no matter how humble the source, and encourages by every means possible the widest spread of the spirit of exact observation.— F. S. EARLE, *Alabama Polytechnic Institute, Auburn, Ala.*

CURRENT LITERATURE.

MINOR NOTICES.

MR. EDO CLAASSEN of Cleveland has published in the fifth annual report of the Ohio Academy of Science a list of the Uredineæ of Cuyahoga and other counties of northern Ohio, together with the names of their hosts. The list includes forty-three species. Also, a second list of the Erysipheæ of the same region, including eighteen species.— C. R. B.

A PAPER by Professor Conway MacMillan in the *Journal of School Geography* for April contains some interesting "Notes for teachers on the geographical distribution of plants," in which the chief principles of ecologic plant geography are sketched, and the suggestion made that such a study of plants has more value in secondary schools than the ordinary herbalism.— C. R. B.

DR. ALBERT SCHNEIDER has published in the *Journal of Pharmacology* for June an account of the histology of the leaves of six species of *Philocarpus* which furnish the various sorts of jaborandi, and also of *Swartzia decipiens* which appears as a substitute. Each species is illustrated by three figures showing the cross section and the upper and lower epidermis.— C. R. B.

A SYNOPSIS of the mosses collected by Dr. Julius Röll in the United States in 1888 has been published by him[1] and distributed by him as a separate. A running account of his trip is followed by a list of species collected. The erratic multiplication of species by Kindberg after competent bryologists have once worked over the material seems to meet Röll's approval, as he gives these names preference.— C. R. B.

THE SEMI-ANNUAL REPORT of Schimmel & Co., dated April 1897, contains a revised list of essential oils, giving their botanical origin, the part or products of the plant from which the oil is obtained, the yield, and the physical constants and principal chemical constituents of each oil. Their first list was published in October 1893. The present one contains a considerable number of oils recently introduced into commerce and the industries. The report is also accompanied by a map showing the regions of Japan producing peppermint oil and camphor.— C. R. B.

[1] Abhandl. d. Naturw. Vereins zu Bremen 14: 183–216. 1897.

MR. JAMES M. MACOUN'S "List of plants known to occur on the coast and in the interior of the Labrador peninsula" includes only spermatophytes and pteridophytes. We hope that ere long botanists will use a less comprehensive term than "plants" when they mean to omit half the subkingdoms from consideration. The list is reprinted from the eighth volume of annual reports of the Geological Survey of Canada.—C. R. B.

THOSE WHO wish to make exchanges in cryptogams or purchase them will do well to consider the terms and inspect the list of the Vienna Bureau of Exchange managed by J. Brunnthaler (Igelgasse 11, Wien IV, 2). The list for 1897 contains over 3000 species. A most reprehensible practice is the publication of diagnoses of new species in a department entitled "Wissenschaftliche Notizen." Thirteen new species of fungi are included in this year's issue, with no indication that they have been described elsewhere. We hope Herr Brunnthaler will prohibit this in future.—C. R. B.

IN ADVANCE of the eighth Annual Report of the Missouri Botanical Garden, we have the first of the scientific papers, an enumeration by M. Jules Cardot of the mosses of the Azores and Madeira, based upon the list of Mitten (1870) and the collections of Trelease and others in 1894–5–6. Eighty Bryales and eight Sphagnales are now known from the Azores, of which nine are new. These are characterized, and figured on eleven plates photo-engraved from the author's drawings. Nineteen Bryales are listed from Madeira, collected by Trelease in June 1896, of which one is new.—C. R. B.

THE EXTRAORDINARY development of the water hyacinth (*Piaropus crassipes* Britt. or *Eichhornia crassipes* Solms) in the St. Johns river, Florida, interferes so seriously with navigation that bills have been introduced in Congress to provide for its eradication. Information on the subject of its introduction, present distribution, and effects on navigation have been gathered by Mr. H. J. Webber under the direction of the Department of Agriculture and is embodied in a bulletin (no. 13) of the Division of Botany. Fortunately the plant is confined to the river named, its tributaries, and a few inland lakes and ponds, but it is a real menace to boats, even to the largest steamers, in the river south of Palatka.—C. R. B.

THE DAHLIA has for many an interest almost as great as the chrysanthemum. Florists who are growing it will be especially interested in a little book which has just been published as one of the series known as Dobbie's Horticultural Handbook.[2] In it will be found chapters on the history of the dahlia, by Richard Dean, F.R.H.S.; the botany of the dahlia, by John Ballantyne; its propagation and exhibition, by Stephen Jones; its cultivation, by

[2] The dahlia; its history and cultivation. 12mo. pp 81, pl. 9. *fig. 1.* London and New York: The Macmillan Co., 1897. 75 cents.

Robert Fife, F.R.H.S.; together with a very complete list of varieties grown in 1896 and prognostigations as to its future, by William Cuthbertson. Although written with English conditions in mind there will be information of value to American cultivators.—C. R. B.

BOTANISTS frequently find in literature reagents and reactions referred to by the names of their authors, and they are often at a loss to know what is meant. For such, a key is afforded by a recent reprint from the *Pharmaceutical Review*.[3] Mr. Richard Fischer has translated Altschul's list of reagents and reactions, about 600 in number, arranged alphabetically under their authors' names, and followed by an index of subjects. The list contains a considerable number of physiological reagents and some of the more important bacteriological ones. Numerous cross references make consultation easy. The repaging of the pamphlet, an annoyance necessitated by the form of the journal from which it is reprinted, might have been partially counteracted somewhat by an indication in the margin of original pagination.— C. R. B.

A BACTERIAL DISEASE of the common squash-bug (Anasa tristis) has been studied by B. M. Duggar[4] at the Illinois State Laboratory. It is readily communicated to chinch-bugs, and is the first genuine bacterial disease of hemipterous insects known. The *Bacillus insectorum* of Burrill, formerly classed as such, has been found to be a normal inhabitant of the cœcal appendages of many insects, and not pathogenic. The germ stains more deeply at the poles, but produces no spores. The growth on agar agar when added to water makes an infusion that is highly toxic to all classes of insects, killing them after a few minutes immersion. On account of this property the germ has been named *Bacillus entomotoxicon*. Mr. Duggar gave some account of this work at the Buffalo meeting of the American Association, an abstract of which will be found in this journal.[5]—J. C. A.

MR. A. J. McCLATCHIE has printed in the *Proceedings of the Southern California Academy of Science*[6] a list of the seedless plants known to occur in the coast region of southern California. The catalogue is preceded by a synopsis of the vegetable kingdom, in which are to be found some novelties in the way of classification, as also in the list itself. One thousand and

[3] FISCHER, RICHARD: Reagents and reactions known by the names of their authors. Based on the original collection by A. Schneider; revised and enlarged by Dr. Julius Altschul for the Pharmaceutische Centralhalle. Translated from the German. 8vo., pp. 82. Reprinted from *Pharmaceutical Review*, 1896, 1897. Milwaukee: Pharm. Rev. Pub. Co. 50 cents.

[4] DUGGAR, B. M.—On a bacterial disease of the squash-bug. Bull. Ill. Lab. Nat. Hist. **4**: 340–379. pl. 27–28. 1896.

[5] BOT. GAZ. **22**: 236. 1896.

[6] McCLATCHIE, A. J.: Seedless plants of southern California. Protophytes–Pteridophytes. Proc. S. Cal. Acad. Sci. **1**: 337–398. 5 Je. 1897. 50 cents.

thirty-three species are enumerated, to which further search will doubtless add many. Among the Agaricaceæ the following new species are described: *Coprinus sulcatus*, *C. sulphureus*, *Hypholoma flocculentum*, *Agaricus bulbosus*, *Pluteolus californicus*, *Pluteus magnus*, *P. californicus*. Artificial keys to the genera of each order are given, which will doubtless greatly increase the usefulness of the list to collectors in this region. We must again express the conviction that such a catalogue is not the place for the publication of new species, nor for the promulgation of new schemes of classification.— C. R. B.

PROFESSOR WARBURG'S new book on the nutmeg[7] is the result of eight years of study and travel. Already a recognized authority on the Myristicaceæ, and with several years of travel and experience in the land of the nutmeg, it is highly fitting that the author should have undertaken a more general work, appealing not alone to botanists, but to all interested in the history, culture, trade, and commercial value of the myristicas. It was Dr. Warburg who first introduced to science the well-known "long nutmeg" of culture (*M. argentea* Warb.), though for many years it had been familiar to commerce as second only in importance to *M. fragans*. It had long been confused by botanists with *M. fatua*, a species of no particular commercial value, and curiously enough this confusion was not finally cleared up until Dr. Warburg found the plant less than ten years ago in New Guinea and gave an exact diagnosis of the species. Interesting and curious bits of historical and traditional information abound throughout the book. Accounts of the discovery of the Banda Islands, the home of the nutmeg, the gradual spread of its culture from the Indian Archipelago over the tropical world, descriptions of the principal nutmegs of commerce, detailed methods of culture, exhaustive compendium of trade statistics, economic products, etc., constitute the general content of the book. The reviewer is at once impressed with the completeness of the work, and the general scientific style and arrangement. Too many so-called monographs of culture plants have in the past been fragmentary, often compilations of similar worthless publications, constituting a hapless mixture of true and false, conjecture finding place indiscriminately with the well established all thrown together without reference or citation.— E. B. ULINE.

NOTES FOR STUDENTS.

A REPORT on the forests of Western Australia[8] by J. Ednie-Brown, F. L. S., conservator of forests, issued as a government publication, contains a large amount of interesting information about Australian trees. The illustra-

[7] WARBURG, O.: Die Muscatnuss, ihre Geschichte, Botanik, Kultur, Handel und Verwerthung.—Roy. 8vo. 40 Bogen, 3 Heliograv., 4 Lithogr., 1 Kart., 12 Textabbild. Leipzig: Wilhelm Engelmann. *M* 20.

[8] BROWN, J. EDNIE.— Report on the forests of western Australia, their descrip-

tions show forest scenes, especially including views of the greatest of Australian trees, the karri. This tree often exceeds 200 feet in height, with a straight trunk 150 feet to the first branch.— J. C. A.

MUSHROOMS AND THEIR USE was the subject of a series of articles by Mr. Charles H. Peck, the state botanist of New York, that were printed in the *Country Gentleman* during 1894. These have now been republished by permission in pamphlet form by the Cambridge Botanical Supply Co.[9] Mr. Peck is a master of the subject, and this excellent account of the different kinds of edible fungi will be especially helpful to those wishing to know them well enough to safely select edible forms.— J. C. A.

MR. G. C. WHIPPLE observes[10] that the growth of diatoms in ponds is directly connected with circulation of the water due to rising or falling temperature. Diatoms do not develop when the lower layers of water are quiet, but grow best when the water circulates from surface to bottom. In deep ponds this occurs chiefly in spring and fall, while in shallow ones there is no regular autumn period. These convection currents affect the growth because in the two conditions of growth a sufficient supply of nitrates and a free circulation of air are so met. Temperature does not affect growth appreciably, nor the distribution of the diatoms according to the season.— C. R. B.

KLÖCKER AND SCHIÖNNING have reexamined the question as to the origin of Saccharomyces.[11] Numerous observers have endeavored to derive the species of this genus from other forms of fungi, and the list includes some distinguished names. But the last investigators have gone over the question with the utmost thoroughness, endeavoring to exclude all sources of error which they believe have vitiated the conclusions of other students. They summarize their results in a word thus: "There is not a single fact known which indicates that the Saccharomycetes are developmental members of other fungi." They rather speak for their being independent organisms, just as the Exoasceæ, since they have morphologically the same developmental forms as these and no others.— C. R. B.

UPON A STUDY of the path of transportation of the constructive materials in plants, Czapek presented a paper to the Imperial Academy of Sciences at Vienna,[12] in which he concludes: (1) Research by means of resection of

tion, utilization, and proposed future management. Roy. 8vo. Perth, 1896. Pp. 57 30 lith. pl., and 1 col. map.

[9] PECK, CHARLES H.— Mushrooms and their use. Cambridge, Cambr. Bot. Sup. Co., 1897. 8vo. Pp. 80. *figs. 32*. 50 cents.

[10] Technological Quarterly **7**: 214–231. *Cf.* Bot. Cent. **69**: 351. 1897.

[11] Compte rendu des travaux du laboratoire de Carlsberg **4**: —. 1896. [livr. 2]. *Cf.* Bot. Cent. **70**: 88. 1897.

[12] Botanisches Centralblatt **69**: 317. 1897.

plates of tissue from the petiole show that the carbohydrates travel stemwards from the lamina in straight lines. Their path is to be found in the straight leptome strands and not in the parenchyma. (2) Research by girdling, retaining an angular interrupted bridge of cortex, shows that the paths in the leptome itself are straight, and that only the sieve cells and companion cells function in this conduction. The leptome parenchyma, including the pith rays, serve for storage. (3) Dead leptome elements, as well as those narcotized with chloroform are [not][13] capable of conduction. On the contrary, plasmolysis does not interfere with their function. (4) Streaming and continuity of the plasma are not to be considered as real factors in the transportation of material by the leptome, since it occurs normally without them. The real impulse is to be sought in the taking up and giving out of the transported substances by the living protoplasm. (5) The acquisition of independence by parts of a plant so as to form separate individuals is as a rule a reaction due to irritability. released by the stoppage of exchanges with the mother individual.— C. R. B.

THE FUNGI OF ALABAMA have been listed by L. M. Underwood and F. S. Earle in Bulletin no. 80 of the Alabama Experiment Station. The list is a remarkably long one, containing 1110 species. The specimens on which the work is based are all accessible; the few not seen by the authors, chiefly of the Berkeley material at Kew, are so indicated, and the original descriptions of the name are usually given. The list represents one year's indefatigable collecting by the two authors, and the published results of the exploration of Professor Atkinson (1889–92) and Judge Peters (1854–64), with a few other random collections of no considerable amount. There are no descriptions of new species, and few notes or changes of name to interest the systematist, but there are some innovations in the nomenclature of the higher groups, and much historical bibliographical, analytical, and descriptive matter, the latter especially interesting to collectors. The divisions recognized are Class, Order, Family, Genus, and Species. The orders have the uniform ending *ales* (*e. g.*, *Mucorales*, *Uredinales*, and two with abbreviated roots — *Hymeniales* and *Gastrales*), while the families take *aceæ* (*e. g.*, *Phallaceæ*, *Lycoperdaceæ*, *Nidulariaceæ*, and *Hymenogastraceæ* of the order *Gastrales*). As a contribution to the fungous flora of a region of which little has been known, the publication is one of unusual importance.— J. C. A.

THREE ANNUAL REPORTS of Experiment Stations for the year 1896 contain many original data and many valuable observations in vegetable pathology, and in a few other subjects. F. D. Chester (Del. **8**: 35–69) gives the results of numerous experiments in treatment of peach blight and rot with Bordeaux mixture and copper acetate, similar treatment of apple scab and

[13] Omitted by typographical error from the report.

spotting of peaches, and observations on apple and cedar rust. Wm. C. Sturgis (Conn. 20: 246–284) in extended trials with corrosive sublimate, lysol, and sulphur for prevention of potato scab, concludes that the first mentioned is the only one that can be recommended. He gives the results of other studies upon this disease as it occurs on potatoes, beets, turnips, mangles, and rutabagas. It does not appear to attack radishes, parsnips, salsify, and carrots. There are also notes upon leaf-blight (physiological) of melons, winter condition of the fungus (*Cladosporium carpophilum* Thm.) causing spotting of peaches, a destructive fungus (*Cercospora Nicotianæ* E. & E.) on tobacco leaves, asparagus rust (*Puccinia Asparagi* DC.), and shelling of grapes (physiological). Geo. E. Stone and R. E. Smith (Mass. 9: 57–84) describe a sporadic attack of a parasitic bacterium in strawberry plants, various forms of spotting of leaves of decorative plants, an anthracnose of cucumbers (*Colletotrichum Lagenarium* E. & H.), asparagus rust (*Puc. Asparagi* DC,), late rust of blackberry (*Chrysomyxa albida* K.), tomato mildew (*Cladosporium fulvum* Cke.), a chrysanthemum rust (*Puc. Tanaceti* S.), drop and top-burn of lettuce, two diseases due in part to disturbed functions and in part to attack of botrytis, and peculiar meteorological conditions causing the wilting and death of maple leaves.— J. C. A.

METHODS OF EBONIZING wood have long been known in the arts, but it is only a few years since ebonized tables have been used in botanical laboratories. Professor Dr. Julius Wortmann describes a cheap and effective method of doing this,[14] which he learned from Mr. A. Jörgensen at Copenhagen. Tables treated in this way have now been in use in the bacteriological laboratory of the University of Wisconsin for some months and have given entire satisfaction. As most microscopic preparations can be better made on a black background, and as these ebonized tables are very resistant to acids and stains, it is probable that they will come to be extensively used when their merits are known. The following directions will enable anyone to prepare them.

Two solutions are needed. Wortmann (l. c.) gives the following receipts for them:

I. 100^{gm} copper sulphate; 50^{gm} potassium chlorate; 615^{gm} water.

II. 100^{gm} anilin chlorate; 40^{gm} ammonium chloride; 615^{gm} water, or:

I. 67^{gm} sodium chlorate; 67^{gm} copper chloride; 1^{l} water.

II. 150^{gm} anilin chlorate; 1^{l} water.

The solutions used in the University of Wisconsin are somewhat different from either, though in effect the same:

I. 125^{gm} copper sulphate; 125^{gm} potassium chlorate; water to make 1 liter.

II. 60^{gm} anilin oil; 90^{cc} hydrochloric acid (c. p.); water to make 500^{cc}.

[14] Bot. Zeitung, 54^{2}: 326. 1 N 1897.

Whichever pair is used, the treatment is essentially the same. The wood is to be painted first with solution I, which is allowed to become just dry; then solution II is applied and allowed to dry in. The process is then repeated. A third application may be necessary to obtain the complete blackening desired. The surface should then be washed with lukewarm water to remove any superfluous salts. After drying, the surface may be finished in oil as untreated wood. When complete it should be a smooth dead black with only the polish due to rubbing.—C. R. B.

IN THE *Botanisches Centralblatt* **69**: 277, 1897, is found an abstract of a Russian paper by Chmilewskij, without citation as to its place of publication, giving an account of researches on the structure and multiplication of pyrenoids in algæ which is worthy of notice. Chmilewskij studied particularly the large pyrenoids of Zygnema. Contrary to Schmitz, he finds, by an examination of sections of the pyrenoid, that the granules of the starch jacket are not separated by chromatophoric substance from the pyrenoid, but that they lie directly against it, fine plates of pyrenoid substance extending out between them, so that the pyrenoid is stellate. In spite of the smallness of the pyrenoids in several other algæ (Spirogyra, Cladophora, Œdogonium, and many Protococcaceæ) he was able to establish the same structure. In Zygnema he ascertained, by a study of living as well as of fixed material, that division of the cell generally precedes that of the chromatophores and pyrenoids, each daughter cell having at first a single chromatophore and pyrenoid, which later undergo direct division. In Spirogyra about dusk, and before the nocturnal cell division, the pyrenoids divide, each forming two or sometimes three or four, often of unequal size. Following this occurs the splitting of the plasma filaments which radiate from the nuclear region and are attached to the peripheral plasma beneath the pyrenoids. This is the reverse of the statement of Strasburger, who states that the pyrenoids are formed where the filaments are attached. In different species of Spirogyra the author determined that in the zygotes the pyrenoids of the female cell persist and can be recognized at any time. No ground for belief in the formation of pyrenoids *de novo* was found. Researches on other algæ are in progress.— C. R. B.

RECENT BULLETINS from the experiment stations of interest to botanists are as follows: H. H. Lamson (N. H. no. 45, pp. 45–56) gives results of use of Bordeaux mixture for apple scab and potato blight, and of corrosive sublimate for potato scab. B. D. Halsted (N. J. no. 120, pp. 3–19) has continued his trials of fungicides for potato scab and for soil rot of sweet potatoes and finds sulphur superior for both. He presents considerable original data. J. C. Arthur (Ind. no. 65, pp. 19–36) reports the successful use of formalin for potato scab. He also gives a method for careful percentage determination of the injury in a crop from scab. S. A. Beach (N. Y. no. 117,

pp. 132–141) reports the result of work during 1896 in treatment of leaf spot of plum and cherry with Bordeaux mixture. F. C. Stewart (N. Y. no. 119, pp. 154–182) presents a comprehensive account of the downy mildew of the cucumber (*Plasmopara Cubensis* (B. & C.) Humph.), especially of its destructive appearance during 1896 upon Long Island, and of a successful treatment with Bordeaux mixture. A. D. Selby (Ohio no. 79, pp. 97–141) writes about a large number of fungous diseases of orchard and garden crops, and also presents a spray calendar as supplement to the bulletin. J. W. Toumey (Ariz. no. 22, pp. 3–32) gives much good advice regarding weeds, and some account of thirteen of the worst weeds of Arizona. H. L. Bolley (N. D., no. 27, pp. 109–164) reports numerous experiments and studies on the smuts of wheat, oats, and barley, extending over a period of three years, and embracing structural and developmental studies, use of hot water, corrosive sublimate, formalin, potassium sulphide, sulphur dioxide, and other treatments, with many practical and technical discussions. G. P. Clinton (Ill. no. 47, pp. 373–412) writes upon broom corn smut, *Ustilago Sorghi*, or, according to the author, *Cintractia Sorghi-vulgaris* (Tul.) Clint. Among the topics studied were the germination of the spores, growth of the smut, infection, successful hot water treatment, together with historical and bibliographical notes. A. D. Selby and J. F. Hickman (Ohio, no. 78, pp. 92–96) give some observations and a general account of corn smut, *Ustilago Zeæ*. F. D. Chester (Del., no. 34, pp. 3–22) records the results of the use of fungicides during the year 1896, especially in use of Bordeaux mixture for peach rot and apple scab, and of sulphur for diseases of potato tubers. L. R. Jones and W. A. Orton (Vt., no. 56, pp. 3–15) give an excellent summary of the distribution and history of the orange hawkweed (*Hieracium aurantiacum*) with practical suggestions. L. H. Pammel (Iowa, no. 34, pp. 656–686) writes about some troublesome weeds of the mustard family. Fred W. Card (Neb., no. 48, pp. 69–96) has studied windbreaks in a scientific manner, and records their effects upon soil moisture, soil evaporation, air conditions, and the growth of adjoining plants.—J. C. A.

A NUMBER of papers of ecological and geographical interest have recently appeared in Scandinavian publications. One of the more important is by Erikson, on the sand flora of the east coast of Scania in southern Sweden.[15] The sand vegetation is of three types: strand, dune, sandy field; the strand and dune floras are characterized by halophytes, the sandy fields by grasses. The plants exhibit the usual xerophyte adaptations, such as annual habit, abundant pubescence, rosette, and espalier forms, deep and often fleshy roots, well-developed underground stems, thick epidermal walls, isolateral assimilatory tissue, thickening of outer root tissues. Ryan and Hagen have made

[15] Bihang till Kongl. Svensk. Vet. Akad. Handl. **22**. No. 3. 77 pp. Stockholm, 1896. See Bot. Cent. Bei. **6**: 512–515.

a study of the mosses in the neighborhood of Smaalen, Norway.[16] Mosses and other cryptogams are too often omitted or insufficiently considered in geographic studies. In this paper are described the various ecological factors, the different moss floras and their associations with varying soil conditions; the mosses are also separated into climatic groups. The prevailing rocks are granite, gneiss, and porphyry, the latter especially having a peculiar moss flora, largely conditioned by the calcareous nature of the porphyry. Grevillius has studied the vegetation of Jerutland near the boundary of Norway and Sweden.[17] The author has made a study of the plant societies on the various rock types, such as aluminous shales, mica slate, limestone, quartzyte, sandstone and granite. The vegetation varies but little as the rock varies. The predominant vegetation throughout is the spruce forest with abundance of mosses and some birches. Such differences as appear where the rocks vary seem to be due largely to the differences in weathering, characteristic of the rock types. Sernander and Kjellmark describe the results of a peat moor study in the Swedish province of Nerike.[18] This study was prompted by the discovery of two northern species of Betula in the moors of Nerike. The paleontological evidence shows that the former flora of the region was driven out by an invasion of northern types, the invasion being due to increasing severity of climate. A return of more genial conditions resulted in the retreat of the northern forms; the species of Betula now present are taken to be relicts of this northern invasion. Nilsson has described coniferous forests in Sweden that have an abundant herbaceous vegetation.[19] Most coniferous forests in Sweden have the soil covered by mosses or lichens; in some cases grasses occur, but herbaceous forests have seldom been noted. The author describes woods in which there is an abundance of perennial herbs, grasses and mosses. Such woods are supposed to have arisen by gradual transitions from alder swamps in which herbs are abundant; it seems likely that the herbs are destined to disappear and that the ordinary mossy forest is the ultimate destiny. The author closes with a survey of the factors influencing the succession of plant societies; one of the chief causes is the constant change of soil that results from plant life. Each species transforms the soil into a substratum that is disadvantageous to itself. Wittrock has made a study of the higher epiphytic vegetation of Sweden.[20]

[16] Det Kgl. Norske Videnskabernes Selskabs Skrifter. No. 1, pp. 1–168. 1896. See Bot. Cent. **69**: 142–144.

[17] Sveriges Geologiska Undersökning. Series C, No. 144. 4to. 16 pp. Stockholm, 1895. See Bot. Cent. **69**: 289–290.

[18] Bull. Geol. Inst. Upsala, **2**: No. 4. 28 pp. 1895. See Bot. Cent. Bei. **6**: 517 519.

[19] Tidskrift för Skogshushållning, pp. 193–209. Stockholm, 1896. See Bot. Cent. Bei. **6**: 515–517.

[20] Acta Horti Bergiani, Band II, Heft 6, 29 pp. Stockholm, 1896. See Bot. Cent. **69**: 288–289.

The author includes only those forms that occur commonly in the soil but are occasionally epiphytic. Six ferns and ninety-seven seed plants are noted. These epiphytes occur most commonly where the trunk branches or near the base. Trees and shrubs are more common than herbs, *Sorbus Aucuparia* being by far the most abundant form. These epiphytes must be adapted to endure a large amount of shade and considerable drouth, and must also be able to take root and grow in shallow soil. Seeds are conveyed to the place of germination by birds, winds, and mechanical fruit contrivances. Plants with heavy seeds are not epiphytic. In connection with studies by Scandinavian botanists there may be noted a paper by Rabot on the limits in altitude of the forests of northern Scandinavia.[21] The country is well fitted for a comparative study of horizontal and vertical forest limits. The maximum heights, of course, decrease northward, but with considerable irregularity, and are not proportional to the latitude. Proximity to the sea is an important factor, the northward decrease being much greater inland than near the coast. Trees ascend considerably higher on a broken mountain chain than on a plateau. The northern limits of the pine, and also the vertical limits on the mountains, have retreated considerably during the past 150 years. Rabot's studies were extended into Russian Lapland.—H. C. C.

[21] Rev. Gen. Bot. **8**:385–417. 1896.

NEWS.

THE TORREY BOTANICAL Club of New York has elected Dr. A. Zahlbruckner of the Imperial Museum of Vienna a corresponding member.

DR. L. M. UNDERWOOD, of Columbia University, and DR. H. H. RUSBY, of New York College of Pharmacy, will spend the summer at Kew.

PROFESSOR S. M. TRACY, having resigned his position as Director of the Mississippi Experiment Station, has changed his address to Biloxi, Miss.

DR. FRITZ MÜLLER, who has done so much to make known the botanical riches of tropical Brazil, died at Blumenau on the 21st of May, at the age of 75.

DR. ALBERT SCHNEIDER has been appointed to the chair of botany, pharmacognosy, and materia medica in the School of Pharmacy of the Northwestern University, Chicago.

THE LAST TWO issues, nos. 17 and 18, of Lloyd's Photogravures of American Fungi give two views of *Scleroderma Corium* Grav. The specimen was collected in Kansas by Mr. E. Bartholomew.

DR. EDUARD FISCHER, who has been assistant professor of botany in the University of Bern, has been promoted to the professorship in place of his father, Professor Dr. L. Fischer, who retires from active work.

MISS BERTHA STONEMAN, a graduate of Cornell University, who has been prosecuting her researches there during the past year, has been appointed to the chair of botany in the Huguenot College for Women in Cape Colony.

ROBERT DOUGLAS, who has for many years conducted an extensive nursery at Waukegan, Illinois, and has done much service in the advancement of arboriculture and forestry, died at his home on June 1st, at the age of 84.

COUNT VICTOR TREVISAN, an Italian mycologist of repute, a native of Padua, died in Mailand on the 8th of April, in the 80th year of his age. He had amassed a large collection of cryptogams, which is very valuable in the results of his critical study.

PROFESSOR RODNEY H. TRUE has begun in the *Pharmaceutical Review* a series of papers on the anatomical characters of native drugs of Ceylon,

based upon specimens exhibited at the Columbian Exposition, which became the property of the School of Pharmacy of the University of Wisconsin.

THE BERLIN ACADEMY of Sciences offers a prize of *M* 2000 for a memoir based upon researches and observations on the origin and behavior of varieties of cereals during the past twenty years. The memoir may be written in German, Latin, French, English, or Italian, and must be presented by December 31, 1898.

THE CHAIR in the College of Pharmacy of Philadelphia occupied by the late Dr. Bastin has been divided. Dr. Low who was Dr. Bastin's assistant has been given charge of materia medica and pharmacognosy, and Professor Henry Kraemer of the Northwestern University is placed in charge of botany and microscopy.

DR. EDMUND RUSSOW, well known for his earlier researches on plant anatomy and his later ones on the Sphagnaceæ, died in Dorpat on the 11th of April. In recognition of his long and eminent services he was appointed some years ago professor emeritus in the University of Dorpat. He was also a councilor-of-state.

LUDWIG, commenting upon Zukal's oversight of Thaxter's Myxobacteriaceæ,[1] previously criticised in this journal,[2] makes matters rather worse for Zukal by pointing out that Thaxter's publication had been abstracted in 1893 both in the *Beihefte zum Botanisches Centralblatt* and *Centralblatt für Bakteriologie und Parasitenkunde.*

THE SECTION of mathematics and natural science of the Prince Jablonowski Society at Leipzig offers a prize of *M* 1000 for the best study of the causes which produce and control the direction of the lateral axes of shoot and root systems. The memoir must be submitted to the secretary of the society by the 30th of November, 1900.

MR. FREDERICK C. STRAUB died in Liberia, Africa, March 21, at the age of twenty-six. He had accompanied Mr. O. F. Cook in 1895 in his botanical exploration of the west coast, and remained there during last summer. He was engaged in collecting plants and in overseeing the plantation that is organized in Liberia for practical educational purposes. He fell a victim to the jungle fever.

[1] Bot. Centralbl. 69: 352. 1897.

[2] 23: 205. 1897.

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BOTANICAL GAZETTE

AUGUST 1897

THE PHALLOIDEÆ OF THE UNITED STATES.

III. ON THE PHYSIOLOGY OF ELONGATION OF THE RECEPTACULUM.

EDWARD A. BURT.

DURING the greater part of its existence, the fructification of a fungus of this strange family is a compact egg-shaped body, the outer part consisting of a thick and highly gelatinous peridial wall, and the inner portion of the receptaculum and spore-mass. This stage of existence of the fructification is usually subterranean or semi-subterranean. As it nears the stage in which elongation sets in, the rapid growth of the receptaculum in its limited space in the peridium throws the chamber-walls of the receptaculum and often, as in *Mutinus caninus*, the wall of the stipe as a whole into complicated folds. When the spores are mature, elongation of the receptaculum occurs by processes to be considered in the present paper, the folds of its walls straighten, and the apex of the receptaculum is pushed outward and upward through the investing peridial wall, irregularly rupturing the latter, which remains, however, connected with the receptaculum at the base and forms a loose bag, the volva, about its lower end. Through elongation of the receptaculum, the spore-mass is carried upward to a position more advantageous for the dispersal of the spores; this seems to be the end attained.

The straightening out of the folds in the chamber-walls of *Phallus caninus* and of *Phallus impudicus* was stated by De Bary to be due, in his opinion, to the inflation of the chambers by the formation of a gas within them.[1] This idea found its way into the text-books.[2]

Such an explanation of the phenomenon has been objected to by Ed. Fischer.[3] He points out that the chambers of the receptaculum are not surrounded by air-tight walls; that all the chambers are open on one side in some species which he has studied; and that there is no visible indication of inflation of the chambers during elongation in other cases. On these grounds he concludes that the walls are not passive in their straightening out, as De Bary's explanation necessitated. That they are the active agents he deduces from the forms of the cells of pseudoparenchyma at the ends of the folds, and from their changes in form as the folds straighten. He gives figures showing that at the inner angle of the fold the cells are wedge-shaped as if by compression, while on the periphery of the fold they are elongated and thin as though stretched there. In his experiments of placing such folds in certain aqueous solutions of slight density, the turgescence of the cells increased by absorption of the liquid, they became more nearly spherical, and the effect of such change of form both at the inner angle of the fold and at its periphery must have been to straighten the fold.

Two years before the publication of Fischer's paper, Errera came to the conclusion incidentally in his work *Sur le Glycogene chez les Basidiomycetes*[4] that elongation of the receptaculum in *Phallus impuditus* results from a true process of growth and not from mere turgescence by the simple absorption of water. A

[1] Zur Morphologie der Phalloideen. Beitrage z. Morph. u. Physiol. der Pilze, Abhandl. d. Senkenb. Naturf.-Ges. 5: 202, 207. 1864.

[2] (*a*) De Bary, Comp. Morph. of the Fungi, etc., Eng. trans. 323.

(*b*) Sachs, Text-book of Botany, Eng. trans. 341.

[3] Bemerk. über d. Streckungsvorgang d. Phalloideenreceptaculums, Mittheil. d naturf. Ges. in Bern, 142. 1887.

[4] Mem. de l'Acad. roy. de Belgique 37 (p. 52 of reprint). 1885.

more detailed reference to his views will be given toward the close of my paper.

The material for numbers 1–5 of the following experiments was collected early in October, 1894, on a grassy slope at Fresh Pond, Cambridge, Mass., a locality to which I was directed by Dr. Thaxter. I am indebted to Mr. A. Piper, a student of Middlebury College, for assistance in procuring the supply with which the investigation has recently been completed. Full grown and apparently mature "eggs" of the species *Dictyophora duplicata* (Bosc) were used. They were collected from time to time just before rains, and were kept in moist paper in a pasteboard box until elongation of the receptaculum was beginning. This was shown by the beginning of rupture of the volva, usually at the apex. Occasionally, however, the rupture occurs so that a portion of the volva is carried upward on the apex of the pileus. When at this stage of development, the plants were then used as indicated below.

Experiment 1.—On October 4, an egg collected October 2 was divided longitudinally into quarters. One of these quarters was put in water, and the other three in aqueous solutions of sugar of 1, 5 and 20 per cent. strength, respectively. The rates of elongation are determined from the respective lengths of the quarters as noted at the hours stated below:

Time	In water	In 1 per cent. sugar sol.	In 5 per cent. sugar sol.	In 20 per cent. sugar sol.
11:00 A. M. - -	56^{mm}	56^{mm}	56^{mm}	56^{mm}
1:15 P. M. - -	94	90	66	62
4:45 P. M. - -	110	106	94	80
8:25 A. M. of next day	114	110	96	83

These results agree with those obtained by Ed. Fischer with *I. impudicus* in various solutions, and they indicate, as he has asserted, that elongation is most rapid in water and in very dilute aqueous solutions, which would be most readily absorbed by the cells of pseudoparenchyma.

Elongation of the receptaculum of these plants is most likely to occur during rainy weather or shortly after rains. This

is the popular belief, with which my observations agree. It suggests the query, is an abundant supply of water needed for elongation of the receptaculum? The following experiment bears on this point:

Experiment 2.—On October 22, an egg collected October 9 was divided longitudinally into halves. One of these halves was placed in a dish of water; the other was placed under a bell jar in a moist atmosphere and was supported on slings in a piece of apparatus devised to avoid the resistance to elongation which would have resulted had this half been allowed to rest on the plane surface of a solid.

The supporting apparatus consisted of a horizontal base—a block of wood—into which a heavy wire was inserted from above. This wire extended upward for a distance of 10 to 15^{cm} and then bent outward and downward, forming a vertical pillar with a supporting arm. To the free end of the arm was then firmly attached the middle of a horizontal rod, the rod being thus held at a suitable distance above the base of the apparatus and in such a position that its ends were equally distant from any point in the supporting column.

The portion of the receptaculum used in the experiment was suspended in a horizontal position below the horizontal bar by two slings, or loops, made of twine. The receptaculum was supported by slipping its opposite ends through their respective slings, which were movable on the horizontal bar. In all the experiments in which this apparatus was used, the slings were adjusted on the bar at short intervals of time so that appreciable resistance should not be offered to the elongation, and also so that the weight of the receptaculum might not exert a pull favoring elongation.

The results of the experiment were as follows:

Time	Length in water	Length in air
10:15 A.M.	47^{mm}	47^{mm}
11:40 A.M.	53	48
1:50 P.M.	120	57
4:45 P.M.	122	92
11:30 A.M. of next day	122	100

In 3 hrs. 35 min. the half in water made an amount of elongation 20^{mm} greater than that made by the half in moist air during 25 hrs. 15 min. The experiment seems to indicate that the rapidity of elongation is favored by an abundant supply of water, but that any very appreciable amount in addition to that already contained in the egg is not, perhaps, absolutely necessary. This experiment was made with the last egg available. The same conclusion, however, had been rendered probable by earlier experiments in which more resistance to its elongation was met with by the half of the egg in the moist atmosphere.

A very large part of the substance of the egg is comprised in the volva itself, the greater portion of which is a thick middle layer, very gelatinous, and containing a large amount of moisture. As already shown, the differentiation of the volva is one of the earliest processes in the development of the egg.[5] At the time of beginning of differentiation of the basidia in *Mutinus caninus*, the middle layer of the volva has already undergone gelatinous modification, and has attained a thickness of about one-third of the diameter of the egg, and has come to inclose the tissue of the future receptaculum and gleba at the top and sides—everywhere except at the very base of the egg where the vegetative mycelium of the fungus is in communication with the more central structures.[6] This relation of the volva to the inner parts is retained through all the later development of the egg until the spores are mature and elongation of the receptaculum occurs. What is the function of the volva? Is it protection? Perhaps such varying external conditions as a hot, dry atmosphere or a flooded condition of the soil during heavy storms are prevented by the thick, gelatinous layer full of moisture from exerting a too direct and injurious effect on the inclosed developing gleba and receptaculum. In staining young eggs for sectioning in my studies of several species of Phalloideæ, I find that aqueous stains do not penetrate through the volva so as to give a good stain to the gleba and receptaculum

[5] BOT. GAZ. **22**: 276. *fig. 4.* 1896.

[6] Ann. of Bot. **10**: 352. *fig. 5.* 1896.

in eggs having the gelatinous layer fully developed. It is necessary to use alcoholic stains. Or, by reason of its slippery middle layer, the volva may give a glancing effect to blows by falling or other objects. Injury to eggs in digging them is not likely to extend beyond the middle layer, and such eggs go through the process of elongation of the receptaculum in an apparently normal manner. Or the volva may contain some substance unpalatable to insects and other animals, and so protect the eggs from being eaten. I have never collected one showing injury of this kind.

On the other hand, is the volva a structure in which water and, perhaps, plastic substances are accumulated as a reserve for use in elongation of the receptaculum? Or may the function of water storage be combined with the earlier one of protection? The following experiments were made to determine whether elongation of the receptaculum is dependent on water or other substance which may be received from the volva during the process of elongation:

Experiment 3.—On October 9, an egg collected October 2 was divided longitudinally into halves. The volva was carefully cut away from one of the halves, care being taken not to injure the base of the stipe. Each half was supported in the apparatus described in *Experiment 2*, and both halves were kept under the same bell jar in an atmosphere kept moist by a strip of damp paper. Rupture of the volva and elongation of the receptaculum began early in the morning, but the apparatus was not ready for use until 10:30 A.M., at which time the partially elongated plant measured about 11^{cm} in length.

Time	Length of half with volva	Length of half with volva removed
10:30 A.M.	111^{mm}	114^{mm}
12:00 M.	116	120
5:00 P.M.	118	124

Experiment 4.—On October 9, a very fine plant, partially elongated, was collected at 4:00 P.M. It was taken to the laboratory at once and divided longitudinally into halves. The

volva was carefully cut away from one of the halves and they were both placed in the supporting apparatus already described. They were covered by a bell jar, but no moist paper was placed under the jar.

Time	Length of half with volva	Length of half with volva removed
5:00 P.M. - - - - -	117^{mm}	116^{mm}
7:30 A.M. of next day -	157	151

Experiment 5.—On October 10, an egg collected October 9 was divided longitudinally. Elongation was just beginning; the outer layer of the volva was ruptured but the innermost was still intact. It was necessary to loosen the volva from the surface of the gleba and the stipe. The volva was carefully cut away from about the base of one of the halves and they were then placed in the supporting apparatus under a bell jar. No moist paper was placed under the jar.

Time	Length of half with volva	Length of half with volva removed
9:15 A.M. - - - - -	46^{mm}	46^{mm}
12:45 P.M. - - - - -	82	81

It seems safe to conclude from *Experiments 3–5* that elongation of the receptaculum does not result from any contribution made by the volva during the process. One must look to the receptaculum itself and to the tissues lying next to its walls for the causes producing it.

The receptaculum walls in this stage consist of pseudoparenchyma so swollen as to show but little trace of its hyphal origin; the chambers contain a tissue highly gelatinous but still showing its hyphal character. The tissue originally occupying the main central cavity of the stipe has the condition of a glairy mass which becomes still more fluid as elongation progresses.

Microscopic examination of one of the folds of the wall just at the beginning of elongation shows that the cells are slightly wedge-shaped at the inner angle of the fold as though compressed, while on the outer surface of the fold they are somewhat flattened as though stretched out there. The cell-like

bodies which are not in the angles of the folds have a more spherical form in general. In a fully elongated stipe the cell-like bodies of pseudoparenchyma are more spherical or ovoid throughout in general, although somewhat irregular.

These facts may indicate, as Ed. Fischer claims,[7] that the straightening of the folds is due to the simple absorption of liquid by the pseudoparenchyma. His theory of elongation of the receptaculum accounts for the increased rapidity of elongation when the receptaculum is immersed in water, as in some of my experiments. It is also favored by the rapid elongation in suitable liquids of slight density, as Fischer has observed. It is not rendered improbable by the occurrence of elongation in an atmosphere containing but little moisture, even though no water supply is being brought up into the plant by the mycelium; for the pseudoparenchymatous walls are found to be constantly moist during elongation, such moisture coming from adjacent gelatinous tissues presumably.

I believe that we may conclude that the straightening out of the folds in elongation is due, in some degree at least, to the change in form—becoming more nearly spherical—of the pseudoparenchyma at the inner angle and the periphery of the folds. But is this change of form due merely to increased turgidity of the pseudoparenchyma by simple absorption of water? May there not be a process of growth going on, as a result of which the change of form occurs?

In his researches on glycogen in Basidiomycetes, Errera[8] gave especial attention to its occurrence in *Ithyphallus impudicus*, and found that in the various stages of that plant the glycogen was most abundant in those parts in which active growth was about to take place. He regards glycogen as a food substance accumulated for use in future growth, and finds that it disappears in the degree that such growth progresses. He found glycogen very abundant in the walls and chambers of the stipe just before elongation began, but it gradually disappeared during elongation, and was wholly lacking except at the base of the

[7] *Loc. cit.* [8] *Loc. cit.*

stipe when elongation was completed. From this he concludes that elongation of the receptaculum is the result of true growth of the pseudoparenchyma, water being used in the process as it is in other growth.

While Errera's treatment of this problem is very suggestive and his explanation very probable, so also is that by simple absorption of water. It has seemed to me that if it can be shown that there is a decidedly general increase in size of the cells of pseudoparenchyma during elongation, the growth theory will be the truer one. If, however, the increase is confined to the pseudoparenchyma in the angles of the folds, the theory of turgescence must be the more correct.

The necessary data for the determination of this point have been obtained by the microscopic measurement of the individual cells of pseudoparenchyma making up the wall in various parts of the stipe. Eggs just beginning elongation or plants partially elongated were divided longitudinally into halves. Thin radial longitudinal sections were then cut free-hand with a razor from the wall of the stipe of one of the halves. After placing the sections in a drop of water, the measurements were immediately noted of the individual cells in a strip extending across the partition wall.

The part of the receptaculum called the stipe or stem in these plants is a hollow cylindrical body with a wall of chambered structure. The chambers are separated from one another by pseudoparenchymatous partition walls 150–300μ thick. Measurements were taken of the pseudoparenchyma in longitudinal partition walls next to the main central cavity of the stipe, at the outer surface of the stipe, between the chambers in the interior of the stipe-wall, at the angles of the folds and at points midway between the angles, and also in transverse partition walls.

The other half of the egg, or partially elongated plant, was kept in the supporting apparatus in a moist atmosphere until the completion of the elongation. Longitudinal radial sections of the stipe-wall were cut, and the pseudoparenchyma then measured at points in the partition walls corresponding to the points

of measurement in the first half. Measurements were made of rather a broad strip across the partition wall to avoid error in the computations through very large or very small cells occasionally found. The individual cells in such a strip were carefully measured by the usual method of measuring spores of fungi, an eyepiece micrometer being employed in the work. The measurements are given in detail at the close of this paper in *Exps. 6–9*, where the several sets of measurements of corresponding parts of the two halves of each specimen are arranged in parallel columns for convenience of comparison. The general results of these experiments are as follows:

In *Exp. 6* the measurements were made on half of a stipe just beginning elongation and on the other half after its completion. The averages of the diameters in the several sets of measurements of the unelongated half vary from 26.7μ to 35.3μ, with a general average of 30.5μ computed on all the measurements. The corresponding averages of the other half after its elongation vary from 32μ to 40.5μ, with a general average of 37.1μ based on all the measurements. These results give an average increase of 22 per cent. in length of diameter of the cells of pseudoparenchyma during elongation of the receptaculum.

Exp. 7 was made with a fine large plant having its receptaculum already partially elongated. The averages of the sets of measurements of pseudoparenchyma from the partially elongated receptaculum vary from 28.5μ to 37.2μ with a general average of 31.3μ based on all the measurements. The corresponding averages of the other half, after the completion of its elongation, vary from 36.6μ to 39μ with a general average of 37.9μ computed from all the measurements. These results show an increase of 21 per cent. in length of diameter of the cells of pseudoparenchyma during the completion of elongation of the receptaculum.

In *Exp. 8*, also made with a plant partially elongated at the beginning of the experiment, the average lengths of diameter of the pseudoparenchyma vary in the partially elongated half from 25.5μ to 32.2μ with an average of 28.5μ determined from all the

measurements. After completion of elongation the corresponding averages vary from 27.2μ to 34.2μ, with a general average of 31.2μ computed on all the measurements. The increase in length of diameter of the cells of pseudoparenchyma was therefore about 9½ per cent. in the completion of elongation of the receptaculum.

Comparison of the results of *Exp. 6* with those of *Exps. 7* and *8* indicates a gradual increase in the size of the cells of pseudoparenchyma during the whole course of elongation of the receptaculum. The purpose for which these measurements were made is to decide, however, whether the cells of pseudoparenchyma at or after the close of elongation of the receptaculum are larger in the same plant than at the beginning, or before the completion of the process. In *Exps. 6–8*, comparison with each other of the sets of measurements of corresponding parts of the stipe-wall for the two periods covered by the experiments shows a marked increase in the size of the cells of pseudoparenchyma by the close of elongation. The increase is not confined to the pseudoparenchyma at the angles of the folds, but is approximately uniform for each part of the same plant, not differing much from the percentage of increase for that plant as computed from all the measurements. In *Exp. 6* the increase of 22 per cent. in the average length of diameter of a cell of pseudoparenchyma gives an increase of 81 per cent. in the volume of the cell. In other words, each cell of pseudoparenchyma becomes nearly twice as large by the close of elongation of the receptaculum as it was at the beginning of that process.

Such a general and great increase in the size of each cell of pseudoparenchyma in every part of the stipe must find its explanation in conditions to which all the cells are alike subjected. As the reserves of glycogen disappear from the cells during the course of elongation, we must conclude that the increase in size of the cells of pseudoparenchyma results from their rapid growth at the expense of the glycogen accumulated in and about the receptaculum, and that such water as is used in the process is most probably used as in other cases of growth. The bursting

forth of the receptaculum from the volva and the straightening out of its folded walls in elongation are due, therefore, to a true process of growth of the pseudoparenchyma, during which the cells of pseudoparenchyma at the angles of the folds grow somewhat more spherical, however, and so become to some extent presumably active agents in the process of elongation.

To one not aware of the vitality of these plants, the question may arise as to whether the longitudinal division of the receptaculum into halves may not have injured the plants to such a degree as to invalidate my conclusions. The elongation is perhaps less rapid when the receptaculum has been so divided, but it seems to become complete. The cells of pseudoparenchyma in such cases attain the full dimensions observed in the pseudoparenchyma of a receptaculum from eggs of the same size and apparent vigor, in which elongation has occurred without division of the receptaculum having been made. Under *Exp. 9* are grouped sets of measurements of the pseudoparenchyma in the receptaculum of a vigorous plant whose elongation was normal and was completed before any incision was made into the stipe. The averages of the lengths of diameter of the pseudoparenchyma vary from 37.7μ to 38.6μ in this case. In *Exps. 6* and *7* the average diameters of the pseudoparenchyma in the halved receptacula at the completion of elongation were respectively 37.2μ and 37.9μ. These three sets of averages agree well; the plants on which they are based were strong plants of about the same size. The specimen used in *Exp. 8* was smaller and slenderer than the others and its pseudoparenchyma cells were also smaller; their average diameter is not probably comparable with those of the specimens used in the other experiments.

The conclusions reached may be summarized as follows:

1. While the rapidity of elongation is favored by an abundant supply of water, still any very appreciable amount in addition to that already contained in the egg is not absolutely necessary.

2. Elongation of the receptaculum is not dependent on any contribution of water or other substance from the volva during

the progress of elongation. The function of the volva is more probably one of protection of the parts it incloses in the egg-stage.

3. During the progress of elongation and coincident with the disappearance of the abundant store of glycogen found by Errera in and about the receptaculum, there is a very rapid and general growth in size of the cells of pseudoparenchyma constituting its walls. The bursting forth of the receptaculum from the volva and the straightening of its folded walls are due to such process of growth of the pseudoparenchyma, during which the cells at the angles of the folds grow somewhat more spherical and so become to some extent presumably active agents in the process of elongation.

ACCOUNT OF EXPERIMENTS 6–9, WITH MEASUREMENTS OF PSEUDOPARENCHYMA.

NOTE.—In the tabulated lists of measurements made in these experiments both the long and short diameters of subspherical or ellipsoidal cells are given. The measurement first given in such cases is in a general direction transversely across the partition wall. For each of such cells one-half the sum of its long and short diameters has been taken as the approximately average diameter for use in computing the general averages. This average diameter is given in parenthesis.

The side of a wall forming a part of the outer surface of the stipe is marked (*a*); the side forming a part of the surface of the main central cavity of the stipe is marked (*c*).

Experiment 6.— A strong egg just beginning elongation was divided longitudinally into halves at 3:00 P.M., October 8. Longitudinal radial sections were cut free-hand from the wall of the stipe of one of the halves. These sections were placed in a drop of water on a slide and measurements were immediately made of the cells of pseudoparenchyma in strips across the partition walls which make up the wall of the stipe. These measurements are given in the column on the left below. The other half of the egg was suspended in the supporting apparatus in a

moist atmosphere until after the completion of elongation. On October 10 at 9:00 A.M., sections were cut from it and measurements of their pseudoparenchyma were made as in the case of the first half. These measurements are given in the column on the right.

Before elongation of the receptaculum.

	μ
	28
	36
	36
	28
Longitudinal wall,	32
	28
	28
	24 x 32 (28)
Average, -	30.5
	28 *c*
	24
	30 x 44 (37)
Longitudinal wall next to central cavity of stipe.	28
	40
	60 x 52 (56)
Average, -	35.5
	36
	28
Longitudinal wall in interior of stipe wall.	32
	20
	32 x 28 (30)
	32
Average, -	29.7

After completion of elongation.

	μ
	48 x 40 (44) *c*
	36 x 40 (38)
	36 x 44 (40)
	40
Longitudinal wall next to central cavity of stipe.	40
	32 x 40 (36)
	40 x 28 (34)
	40 x 32 (36)
	40 x 28 (34)
	30
	48 x 30 (39)
Average, -	37.4
	40 *c*
	36 x 52 (44)
Longitudinal wall 220μ thick next to central cavity of stipe.	40 x 52 (46)
	44 x 40 (42)
	44
	48 x 34 (41)
	40 x 38 (39)
	28
Average, -	40.5
	28
	52
	52
	32
	28
	44 x 24 (34)
	40
	40
Longitudinal wall 360μ thick in interior of stipe wall.	36 x 32 (34)
	32 x 48 (40)
	32 x 40 (36)
	40 x 36 (38)

Before elongation of the receptaculum.	μ	After completion of elongation.	μ
			32 x 44 (38)
			40
			36 x 48 (42)
			30 x 40 (35)
			40
			32
			20
		Average, -	36.9
			32
			26
			56 x 40 (48)
		Longitudinal wall	40 x 48 (44)
		220μ thick in outer	32
		surface of stipe.	48
			40
			44 x 60 (52)
			30
			28 *a*
		Average, -	38.8
	24		36
Transverse parti-	32	Transverse parti-	36
tion wall in interior of	24	tion wall in interior	32
stipe wall.	24	of stipe wall.	24
	28		36
	28		28
Average, -	26.7	Average, -	32
			28
			32
			36
		Transverse parti-	28
		tion wall.	36 x 44 (40)
			44
			44
			32
		Average, -	35.5

The measurements of pseudoparenchyma before elongation give 30.5μ as the average length of diameter of the cells in that

stage. After completion of the elongation, the corresponding average length is 37.1μ. These averages show an increase of 22 per cent. in length of diameter of the cells of pseudoparenchyma during elongation of the receptaculum.

Experiment 7.—On October 14, an egg just beginning elongation at 1:00 P.M. had partially elongated to the length of 83^{mm} at 2:30 P.M. The plant was then split longitudinally into halves. Sections were cut from the stipe of one of these halves, and measurements of its pseudoparenchyma were taken as in *Experiment 6.* The measurements are given in the column on the left below. The other half was suspended in the supporting apparatus in a moist atmosphere and had completed its elongation at 4:00 P.M., October 15. It then measured 113^{mm} in length. Sections were cut from its stipe; the measurements of their pseudoparenchyma are given below in the column on the right.

Before completion of elongation.	μ	After completion of elongation.	μ
	20 *c*		28 *c*
	22		36
	52 x 40 (46)		48 x 40 (44)
Longitudinal wall 220μ thick, next to central cavity of stipe and midway between angles.	24	Longitudinal wall 240μ thick, next to central cavity of stipe and midway between angles.	32
	28		44
	40 x 28 (34)		48
	32		44 x 28 (36)
	40 x 56 (48)		36 x 34 (35)
	28	Average, -	37.9
	20		
	28		
Average, -	30		
	26 x 40 (33) *c*		48 x 40 (44) *c*
	44 x 36 (40)		40 x 32 (36)
Longitudinal wall 240μ thick, next to central cavity of stipe and near cross wall.	40	Longitudinal wall 240μ thick, next to central cavity of stipe.	44 x 32 (38)
	32		56 x 64 (60)
	44		36
	32		36 x 48 (42)
	52 x 48 (50)		40
	40 x 32 (36)		28 x 40 (34)

Before completion of elongation.

	μ
	28
Average, -	37.2
	32
	32
	36
Longitudinal wall	40
200μ thick in interior	32
of the stipe wall.	24
	24
	32 x 28 (30)
	44 x 32 (38)
	24
Average, -	31.2
	28
	36 x 28 (32)
	24
	36
	34
Longitudinal wall	16 x 24 (20)
240μ thick in outer	34
surface of stipe.	28 x 26 (27)
	36
	44 x 36 (40)
	16
	20 x 28 (24)
	28 x 10 (19)*a*
Average, -	28.5

After completion of elongation.

	μ
	40 x 28 (34)
	24 x 28 (26)
Average, -	39
	34 x 28 (31)
	36 x 30 (33)
	48
Longitudinal wall	44 x 40 (42)
200μ thick in interior	32 x 28 (30)
of stipe wall.	48 x 40 (44)
	36
	40
Average, -	38
	44 x 40 (42)
	56 x 40 (48)
	40
	44 x 40 (42)
	40 x 32 (36)
Longitudinal wall	32 x 24 (28)
260μ thick, in outer	44 x 32 (38)
surface of stipe and	24
near cross wall.	60 x 28 (44)
	24 *a*
Average, -	36.6

In this plant all the measurements of pseudoparenchyma made before the completion of elongation, give 31.3μ as the average length of diameter of the cells in that stage. After completion of elongation, the corresponding average length is 37.9μ. These results show an average increase of 21 per cent. in length of diameter of the cells of pseudoparenchyma during completion of elongation.

Experiment 8.—On October 14, a small egg just beginning

elongation at 8:00 A.M. had partially elongated to the length of 75^{mm} at 10:00 A.M. The plant was then split longitudinally into halves. Sections were cut from the stipe of one of the halves as in the preceding experiments and measurements of the pseudoparenchyma were made. These measurements are given below in the column on the left. The other half of the plant was suspended in the supporting apparatus in a moist atmosphere until the completion of elongation of its receptaculum, when it measured 100^{mm}. Sections were cut from its stipe at 3:00 P.M., October 15; the measurements of their pseudoparenchyma are given below in the column on the right.

Before completion of elongation.

	μ
	28 x 40 (34) c[9]
	28
Longitudinal wall	40 x 52 (46)
next to central cavity	32
of stipe and in an	44 x 40 (42)
angle.	24
	28
	32 x 24 (28)
	28
Average, -	32.2

	24
	30
Longitudinal wall	32 x 28 (30)
160μ thick in interior	32
of stipe wall.	28 x 16 (22)

After completion of elongation.

	μ
	24 c
	24
Longitudinal wall	36
200μ thick, next to	36 x 52 (44)
central cavity of	32
stipe.	36 x 32 (34)
	36 x 20 (28)
Average, -	31.7

	44 c
Longitudinal wall	20
200μ thick, next to	40 x 32 (36)
central cavity of	32 x 40 (36)
stipe and at a point	36
near a cross wall.	40 x 36 (38)
	40 x 32 (36)
	28
Average, -	34.2

	16
	28
Longitudinal wall	32
160μ thick in inte-	44
rior of stipe wall.	36

[9] In periphery of an angle.

Before completion of elongation.	μ	After completion of elongation.	μ
	26		44
	26		26
Average, -	27.1	Average, -	32.3
			28
		Longitudinal wall in interior of stipe wall at a point mid-way between cross walls.	44 x 40 (42)
			28
			36 x 28 (32)
			28 x 26 (27)
			28 x 24 (26)
		Average, -	30.7
	24		24
	24 x 20 (22)		28
Longitudinal wall in outer surface of stipe.	24 x 32 (28)	Longitudinal wall 160μ thick in outer surface of stipe.	28
	24 x 28 (26)		32 x 36 (34)
	24 x 32 (28)		28 x 24 (26)
	36 x 20 (28)		32 x 28 (30)
	28		32 x 24 (28)
	20 *a*		20 *a*
Average, -	25.5	Average, -	27.2

In this plant all the measurements of pseudoparenchyma from the partially elongated stipe give 28.5μ as the average length of diameter of the cells in that stage. After completion of elongation, the corresponding average length is 31.2μ. This is an increase of 9.5 per cent. in length of diameter of the cells of pseudoparenchyma during the later stages of elongation.

Experiment 9—To determine whether the longitudinal division of these plants into halves, as in *Experiments 6–8*, results in the development of the pseudoparenchyma to an abnormal size. The following measurements were made of pseudoparenchyma from the receptaculum of a vigorous plant whose elongation was normal and was completed before any incision was made into the stipe.

μ	μ
28	20 x 32 (26)
40	40 x 52 (46)

	μ		μ
	48	Transverse parti-	28
Longitudinal wall.	48 x 36 (42)	tion wall in interior	40 x 48 (44)
	40	stipe wall.	40 x 48 (44)
	28		40 x 36 (38)
	44	Average, -	37.7
Average, -	38.6		

Is has already been pointed out that these averages agree well with those of *Experiments 6* and *7*, in which equally vigorous plants were used.

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THE DEVELOPMENT OF THE STAMENS AND CARPELS OF TYPHA LATIFOLIA.[1]

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(WITH PLATES IV–VI)

SINCE the Typhaceæ are perhaps to be considered among the lowest of the monocotyledons, and show some rather peculiar characters in connection with their inflorescence, it seemed desirable to study the history of the development of the stamens and carpels from the very earliest appearance of these organs to their mature condition. Such a study should give some hints as to whether the peculiar floral structures are to be regarded as primitive or reduced.

The material used was killed in chrom-acetic acid and in Flemming's fluid, and preserved in 70 per cent. alcohol. The paraffin method of imbedding was employed, and the sections were stained on the slide. The stains used were anilin-safranin and gentian-violet, iron-alum-haematoxylin, and Delafield's haematoxylin. Because of the extremely small size of the cells, Typha is not a favorable type for cytological study, and a high power is needed to make out even the ordinary cell structures. Some difficulty was experienced in imbedding the older stages, which was overcome, however, by imbedding rather large pieces of the spikes and afterwards cutting away the hard woody stems, when sections could be obtained containing a large number of stamens or carpels.

I am indebted to Dr. John M. Coulter for assistance and valuable suggestions.

The Typhaceæ, as might be expected from their aquatic habit, have preserved many of the characteristics which may be regarded as primitive. The indefinite number of the flowers

[1] Contributions from the Hull Botanical Laboratory, VI.

with spiral arrangement, with no definite perianth and often entirely naked, combined with the anemophilous habit, certainly indicate a condition somewhere near the beginning of flowering plants. The prominent leaf sheaths, which furnish protection and take the place of a perianth, are little modified from ordinary leaves, and the sporophores are without doubt cauline structures.

DEVELOPMENT OF THE STAMENS.

In the very young spike the beginnings of the stamen clusters appear as irregularly projecting outgrowths from the sides of the axis (*figs. 1, 2*). These are of various shapes and sizes, depending upon the number of branches the future stamen cluster is to contain. Soon the branching begins to make its appearance by smaller wartlike processes developing on the primary projections from the axis. The separate stamens or branches attain quite a size before any difference can be detected in their cells to indicate the primary sporogenous cells (*figs. 3, 4*). Indeed, although one may feel sure that certain cells represent the primary sporogenous layer by their position, it would be quite arbitrary to draw any line and call some cells sporogenous and others not. After the stamen has increased somewhat in size, the sporogenous cells may be distinguished more readily by their position and size, although there is no apparent difference in their structure (*fig. 5*). At this stage several layers of cells are already differentiated in this way, and it appears that division may be going on both on the inner and outer parts of the sporogenous tissue (*fig. 5*). It was not possible for me, with the stages at hand, to determine the origin of the tapetum, and the layers of cells between the tapetum and the epidermis. When the stamen is in the early pollen mother cell stage the tapetum is already cut off, and between it and the endothecium is a single layer of cells (*figs. 6, 7*). As the stamens with the sporangia enlarge, the tapetum begins to increase in size also, although it does not take on its glandular appearance until the pollen mother cells have separated (*figs. 8,*

9). While the pollen mother cells are growing and forming the tetrads, the tapetal cells increase greatly in size, and the nucleus of each cell usually divides into two. Toward the end of this process the layer between the tapetum and the endothecium breaks down, and the enlarged endothecial cells are multinucleate (*fig. 10*).

The multinucleate condition is also quite normal in the peculiar stellate cells of the leaves (*fig. 11*). From such appearances it might be inferred that the multinucleate condition stands in some relation to the increase in the volume of the cell.

After the tetrads are formed, the tapetal cells disintegrate, and at the same time the endothecial cells begin to acquire their characteristic thickenings (*figs. 12–14*). At the points where dehiscence is to take place no thickenings are developed (*fig. 13*). As appears from the mode of development, the stamen clusters do not represent a coalescence of filaments, but are cauline in origin. Sometimes as many as five or more stamens branch thus from a common axis. The hairs of the staminate spike are not situated on the stamen clusters, but directly on the axis (*fig. 15*). They are multicellular, and in a cross section usually from fifteen to twenty cells can be counted (*figs. 16, 17*).

DEVELOPMENT OF THE MALE GAMETOPHYTE.

After the pollen mother cells have separated, the tetrads are formed by three usually successive divisions (*figs. 18–20*). The microspores, as is well known, do not separate, but begin immediately to develop very thick cell walls (*fig. 21*). The tetrad pollen grains are often irregular in shape, and do not form a typical tetrad (*fig. 22*). Such forms are no doubt produced by a partial separation of the spores. When the spores germinate the two nuclei are about the same size (*fig. 22*), but later the vegetative nucleus increases in size and the generative nucleus sinks to one end of the pollen grain and organizes a definite cell, being cut off from the rest of the grain by a very

definite cell wall (*figs. 23, 25, 26*). Each grain of the pollen tetrad has a bare, circular, germinating pore for the exit of the pollen tube (*fig. 24*). Although it is generally stated that the tetrads in *Typha latifolia* do not separate until after shedding, I often found them in large numbers entirely separated for some time before the anther was ready to dehisce (*figs. 25, 26*). This cannot be given, therefore, as a character to separate it from *T. angustifolia*, as is frequently done.

DEVELOPMENT OF THE CARPEL.

The carpels originate in a manner quite similar to the stamens, appearing first as small irregular papilla-like protuberances on the axis (*figs. 27, 28*). As the young branch, which is destined to become the carpel, increases in size, irregular outgrowths appear on its sides, which represent the beginnings of the carpellary hairs. These are entirely epidermal in origin, and are produced in acropetal succession, being irregularly arranged on the axis (*figs. 29, 32, 44*). It is not at all probable that such irregular epidermal appendages represent reduced perianth structures, and I am inclined to regard these hairs as having merely a physiological significance, developed for the protection and dissemination of the seed. After the carpellary branch has attained some size, there arises on its summit an annular zone, leaving a deep depression, on the inner face of which the nucellus is developed, while the part of the ring opposite the nucellus develops into the spatulate stigma (*figs. 32, 34*).

The nucellus is lateral in position and soon becomes pendulous because of its downward growth and the increase in depth of the cavity below (*figs. 33–38*). The ring above the nucellus is soon constricted, leaving little if any opening to the exterior (*figs. 33, 37*). After the integuments begin to appear the ovule gradually takes on its anatropous condition until the nucellus is turned outward and points in exactly the opposite direction from its original position (*figs. 38–48*). The integuments are two in number, although the outer one is not developed on the side

toward the funiculus. The ovule receives a fibrovascular bundle which, as it leaves the funiculus, passes down through the wall of the carpel (*fig. 48*) and unites below with the bundle which passes up on the other side into the leaf-like stigma. From this it appears that the ovule is an axillary structure developing at the end of a fibrovascular bundle which represents a branch of the main bundle of the carpel.

DEVELOPMENT OF THE MACROSPORE AND FEMALE GAMETOPHYTE.

In the young nucellus there can be distinguished, at a very early stage, a hypodermal cell which is somewhat larger than the surrounding nucellar cells (*fig. 33*). This, as its subsequent history shows, is the archesporial cell. This cell divides and cuts off one primary tapetal cell (*fig. 35*), and subsequently the primary tapetal cell divides by a vertical wall, forming a tapetum of two cells (*figs. 37–41*). In the rear of the primary sporogenous cell, or the macrospore mother cell, a long axial row of cells is developed (*figs. 38–41*). Often, if the section is not quite longitudinal, so that only three or four of the cells of the axial row are left back of the macrospore mother cell, there is an appearance as though there were a row of four or five macrospores. It is evident that extreme care must be taken not to mistake the large cells of the axial row for potential macrospores. It is possible that misinterpretations may sometimes have been made in this way. In Typha I was only able to determine conclusively the real fate of the macrospore mother cell by tracing out its development step by step, so closely did the cells of the axial row agree in size, structure, and staining reaction with the macrospore mother cell. The macrospore mother cell develops directly into the fertile macrospore without any division, and soon after the integuments have made their appearance it begins to encroach upon the tapetal cells which are destroyed in a short time (*figs. 41–43*).

It is surprising that Typha, which represents such a primitive condition in the organography of its flowers, should represent what must be regarded as a highly modified archesporial region

One would be prepared to expect at least several archesporial cells and some division of the macrospore mother cell. The only thing which reminds one at all of a primitive condition is the division of the primary tapetal cell by a vertical wall. Were one to compare Typha, in this respect, with Salix and Ranunculus, it would appear as a more modern form than either of them. And were one to take the Typhaceæ as primitive representatives of monocotyledons and the Ranunculaceæ and Salicaceæ as ancient representatives of dicotyledons, an inference might be drawn favorable to the derivation of the monocotyledons from the dicotyledons. But such deductions, based on single characters, are treacherous and cannot be taken seriously.

A complete series of stages was not at hand to trace out in detail the development of the embryo sac. The macrospore continues to enlarge until the ovule has become almost completely anatropous before any division takes place. The nucellus beyond the macrospore consists of a single layer of epidermal cells, there being no periclinal divisions (*figs. 45–47*). In the fully developed embryo sac just before fertilization the synergids are well formed, with the oosphere lying immediately behind them (*figs. 49, 51*). The three antipodals are already left in a cæcum-like pocket at the lower part of the sac, while no definite cell walls can yet be distinguished (*figs. 50, 52*). The behavior of the antipodals in Typha, therefore, seems to be the same as has been found for *Sagittaria variabilis*, *Lilium Philadelphicum*, and some other monocotyledons, where the same kind of a pocket is developed for the antipodals.

The two polar nuclei come in contact somewhere near the middle of the embryo sac and fuse there before the pollen tube enters the sac (*figs. 49–53*). In this case, therefore, the definitive nucleus is formed without any stimulus from the entrance of the pollen tube, and it may be questioned whether such stimulus is ever necessary for the complete fusion of the polar nuclei.

It is not necessary, in this connection, to discuss the literature pertaining to the Typhaceæ, although most of the views

here presented have been published before. Those who desire to know the history of the various views will find the appended bibliography helpful.

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EXPLANATION OF PLATES IV–VI.

The plates are reduced two-thirds. The magnifications given refer to the original magnifications of the drawings before reduction. The combinations used were for the most part a $\frac{1}{12}$ Leitz immersion objective, and nos. 2, 4, and 12 Reichert oculars.

Plate IV.

FIG. 1. Longitudinal section of stem, showing the origin of the young stamen branches. × 135.

FIG. 2. Longitudinal section of young stamen branch. × 780.

FIG. 3. The same a little older. × 780.

FIG. 4. Cross section of young stamen at the same age as *fig. 3*. × 780.

FIG. 5. Longitudinal section of young stamen, showing sporogenous cells. × 1200.

FIG. 6. Young stamens with pollen mother cells in the sporangia. × 135.

FIG. 7. Longitudinal section of stamen, showing pollen mother cells, tapetum, endothecium, epidermis, and one layer of cells between the tapetum and the endothecium. × 1200.

FIG. 8. Cross section of microsporangium, showing the pollen mother cells and tapetum. × 1200.

FIG. 9. Cross section of microsporangium, showing the pollen mother cells somewhat separated. × 1200.

FIG. 10. Cross section of microsporangium, showing the disintegration of the immediate cells. × 1200.

FIG. 11. Section of a young leaf showing multinuclear stellate cells. × 650.

FIG. 12. Cross section of microsporangium, showing disorganization of the tapetal cells. × 1200.

FIG. 13. Cross section of an anther just before dehiscence. × 650.

FIG. 14. Longitudinal section of the wall of the microsporangium. × 1200.

FIG. 15. A young branched stamen, showing the position of the hairs. × 40.

FIG. 16. Cross section of one of the interstaminate hairs. × 1200.

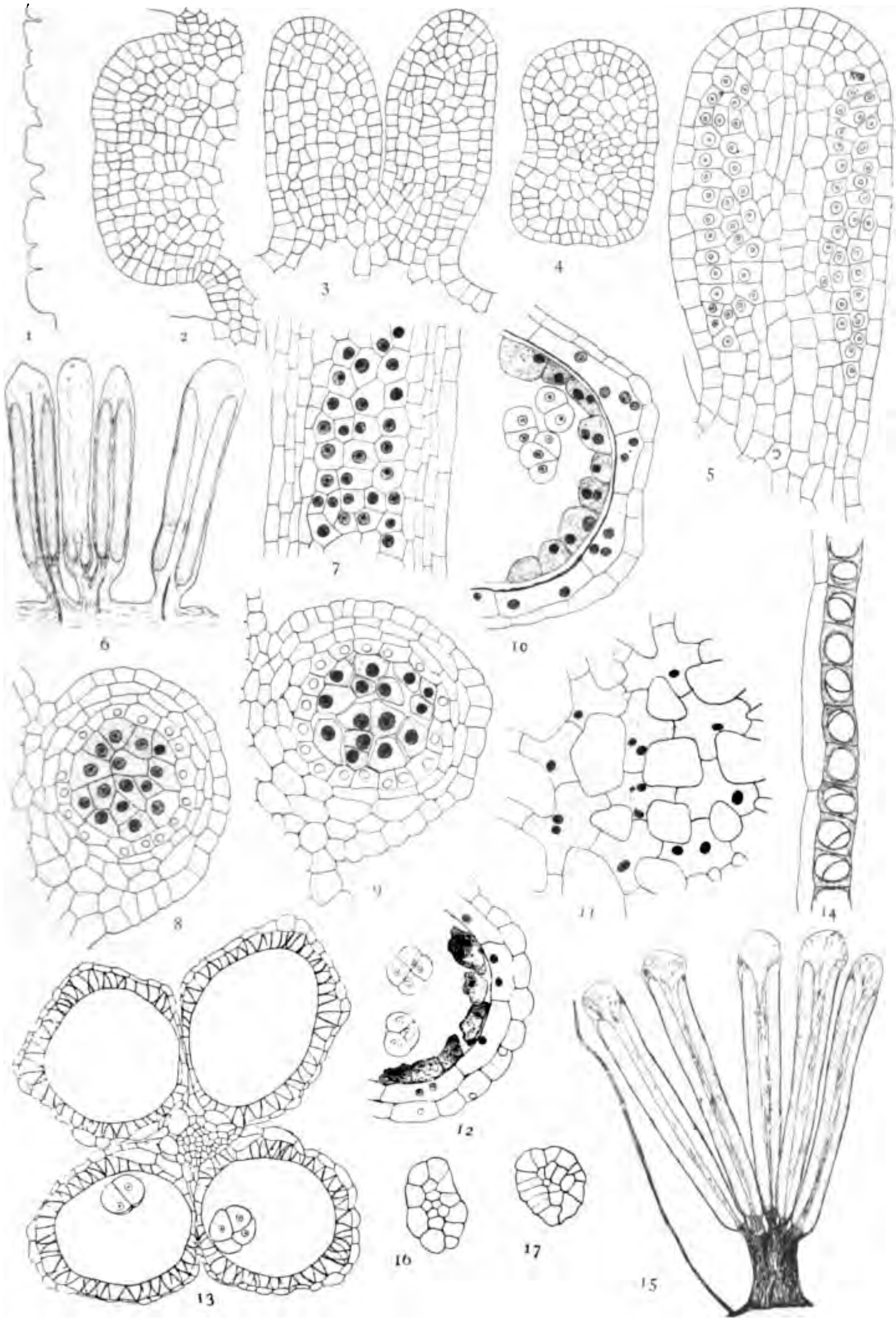
FIG. 17. The same. × 1200.

Plate V.

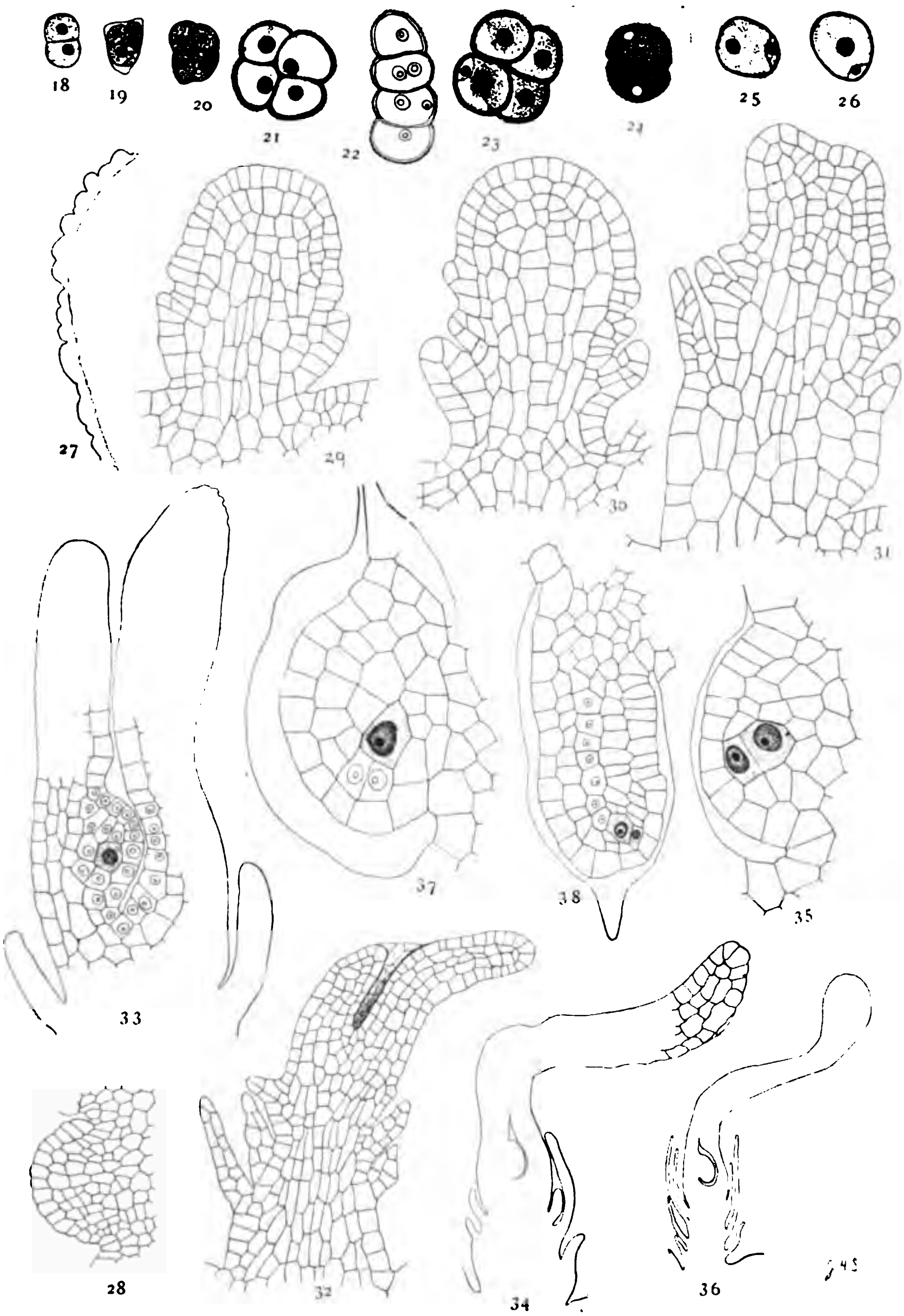
FIG. 18. First division of the pollen mother cell. × 1200.

FIG. 19. Second division of the pollen mother cell. × 1200.

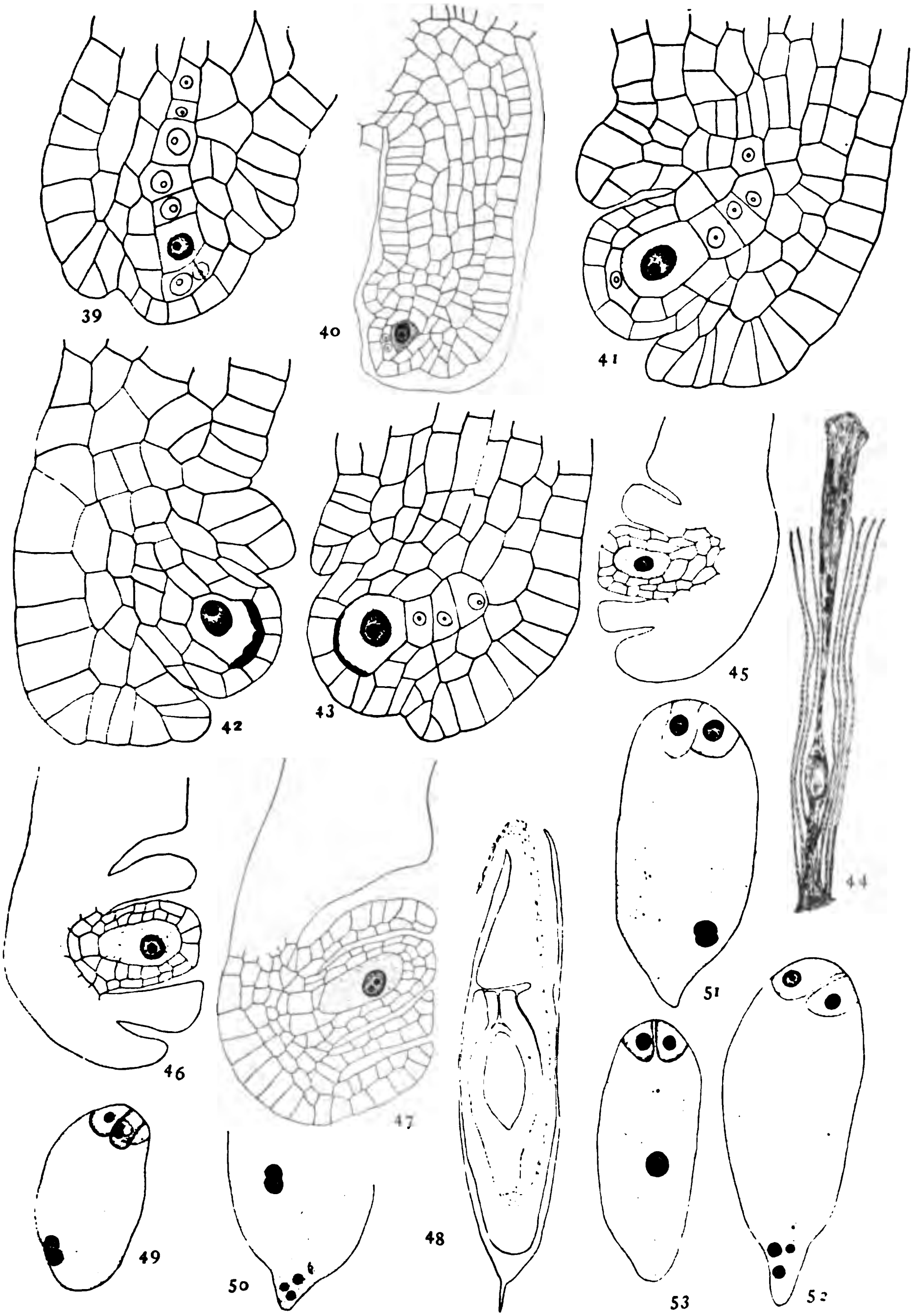
FIG. 20. Tetrad. × 1200.



SCHAFFNER on TYPHA LATIFOLIA.



SCHAFFNER on TYPHA LATIFOLIA.



SCHAFFNER on TYPHA LATIFOLIA.

FIG 21. Tetrad with one-celled microspores with very thick walls. × 1200.

FIG. 22. Irregular pollen tetrad. × 1200.

FIG. 23. Nearly mature pollen tetrad. × 1200.

FIG. 24. Two pollen grains showing circular germinating pores. × 1200.

FIG. 25. Pollen grain before shedding, showing the generative cell and tube nucleus. × 1200.

FIG. 26. The same. × 1200.

FIG. 27. Outline of cross section of stem showing the origin of the carpels. × 135.

FIG. 28. Longitudinal section of young carpel. × 650.

FIG. 29. Longitudinal section of young carpel, showing epidermal origin of the hairs which are produced in acropetal succession. × 1200.

FIG. 30. Section of carpel a li:tle older. × 1200.

FIG. 31. Section of carpel showing the annular zone which gives rise to the ovary cavity. × 1200.

FIG. 32. Section of carpel just before the appearance of the nucellus × 780.

FIG. 33. Section of carpel showing the origin of the nucellus with one archesporial cell. × 1200.

FIG. 34. Section of carpel a little older. × 420.

FIG. 35. Nucellus with primary tapetal cell and macrospore mother cell × 2250.

FIG. 36. Section of carpel. × 200.

FIG. 37. Nucellus, showing the primary tapetal cell divided into two × 2250.

FIG. 38. Section of nucellus, showing a long axial row back of the macrospore mother cell. × 1200.

Plate VI.

FIG. 39. Section of nucellus, showing origin of the integuments. × 2250.

FIG. 40. Section of nucellus a little older than *fig. 38*. × 1200.

FIG. 41. Section of nucellus, showing the macrospore mother cell developing directly into the fertile macrospore. × 2250.

FIG. 42. Section of nucellus showing disorganization of the two tapetal cells. × 2250.

FIG. 43. Section of nucellus, showing further disorganization of the tapetal cells. × 2250.

FIG. 44. Section of a carpel, showing position of the hairs and the ovule. × 80.

FIG. 45. Section showing the ovule becoming anatropous. × 1200.

FIG. 46. Section showing further development of the ovule. × 1200.

FIG. 47. Section of ovule somewhat diagonal, which accounts for the cells appearing between the macrospore and epidermis at the micropylar end. × 1200.

FIG. 48. Section of a carpel, showing position of the ovule at the time of the mature embryo sac. × 420.

FIG. 49. Section of embryo sac, showing egg apparatus and the two polar nuclei in contact. × 1200.

FIG. 50. Section of embryo sac, showing the antipodal nuclei and conjugating polar nuclei. × 1200.

FIG. 51. Section of embryo sac, showing one synergid, the oosphere, and the conjugating polar nuclei. × 1200.

FIG. 52. Section of embryo sac, showing the synergids and antipodal nuclei. × 1200.

FIG. 53. Section of embryo sac, showing the synergids and the definitive nucleus. × 1200.

BRIEFER ARTICLES.

THE "SOFT SPOT" OF ORANGES.

(WITH PLATE VII)

In almost any box or lot of oranges in our markets there may be found some specimens which have begun to decay. This decay always begins and proceeds in a definite and characteristic manner, and is common in oranges everywhere, but so far as I can find out its cause has never been determined.

The first sign of the rotting is a slightly discolored spot on the rind, which becomes soft and pulpy at this point. This spot rapidly increases in extent, so that finally the whole orange is reduced to a rotten, mouldy mass, the decay also often extending to other oranges, if they be packed close together. The decayed area is at first but little different in appearance from the unaffected, but soon it becomes covered with a downy, mold-like covering which is white at first, later becoming an olive brownish color. After the orange has reached an advanced stage of decay various molds appear upon it and produce a variety of colors. The rotting affects principally the rind and also the central core-like portion. It does not extend deeply into or proceed rapidly in the fleshy portion, but produces in it a bitter flavor.

To ascertain the cause of this decay flasks of orange gelatin, prune juice, and prune bread were inoculated with small pieces of the decaying rind taken from the inner portion which had not been exposed to the air. In each case a mold-like mycelial growth was rapidly produced from the point of infection, which soon covered the whole nutrient substance. This mycelium was at first white, changing later to olive brown. Microscopic examination showed that this mold was evidently a species of Penicillium, but not the ordinary *P. glaucum*. It differed from the latter in color, and also in the size and shape of the spores, those of *P. glaucum* being spherical and about 4 μ in diameter, while these were elongated and $10\text{–}13 \times 6\ \mu$. The described species nearest to this form seems to be *P. digitatum* Fr., Saccardo's description of

which applies very well except as regards the size of the spores which he gives as 6 μ in diameter. Notwithstanding this slight discrepancy I judge from the general description that our species is *P. digitatum*, or at least a form of it, an opinion which is corroborated by that of Mr. J. B. Ellis, to whom specimens were sent for determination.

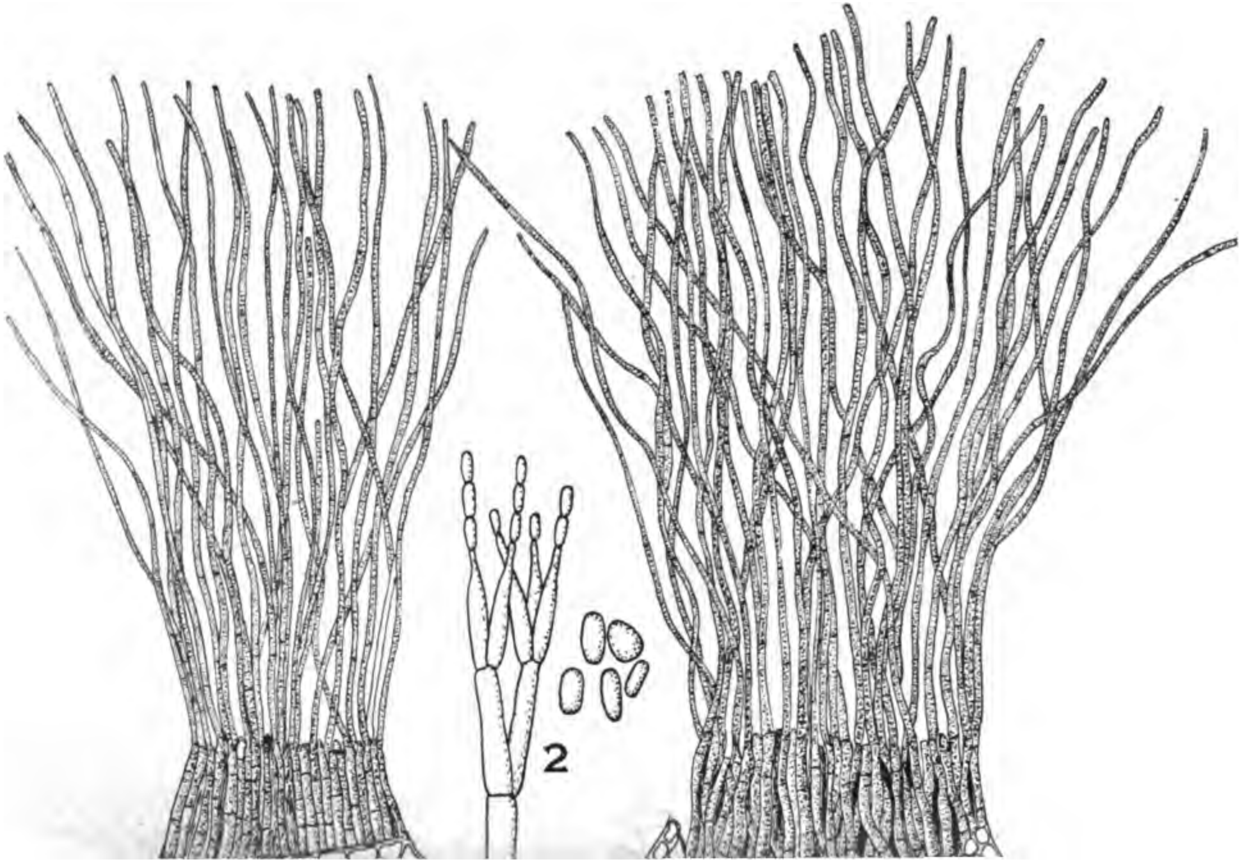
After isolating this fungus attempts were made to produce the decay in sound oranges by infection with spores from artificial cultures. In some cases the spores were simply placed on the rind without puncturing it, while in others the rind was broken. The same was also tried with spores of *P. glaucum*. In each case the oranges were placed in a moist chamber to ensure the germination of the spores. These experiments showed that the characteristic decay is produced by *P. digitatum*, but not by *P. glaucum*, though the latter may come in eventually and much more readily where the rind is injured. It was also found to be greatly favored by a moist atmosphere and close packing together of the fruit.

In the accompanying plate there is shown an enlarged section of the decaying orange rind. Ramifying through the cells are seen the numerous very large filaments which produce the decay. At the surface the filaments aggregate here and there into little pustules which send out clusters of aerial hyphæ as shown in the figure. These form the white mold which appears on the surface of the decaying fruit. On the ends of these filaments the spores are produced (as shown at *2*), which give the mold its brown color.

It is interesting to note that since these studies were made the laboratory where they were carried on has become thoroughly infested with *P. digitatum*, which appears at every favorable opportunity, even more commonly than *P. glaucum*.—RALPH E. SMITH, *Mass. Agricultural College.*

NOTES ON NEW MEXICAN FLOWERS AND THEIR INSECT VISITORS.

PROFESSOR HERMANN MÜLLER, in *The Fertilization of Flowers* 570, remarks that in his experience it was rare to find a particular insect visiting exclusively or almost exclusively a particular flower. He cites only seven instances of this sort, all bees. Dours, in his monograph of the bee genus Anthophora (1869), remarks: "Quelques-unes, toutefois, fréquentent avec plus de prédilection les mêmes espèces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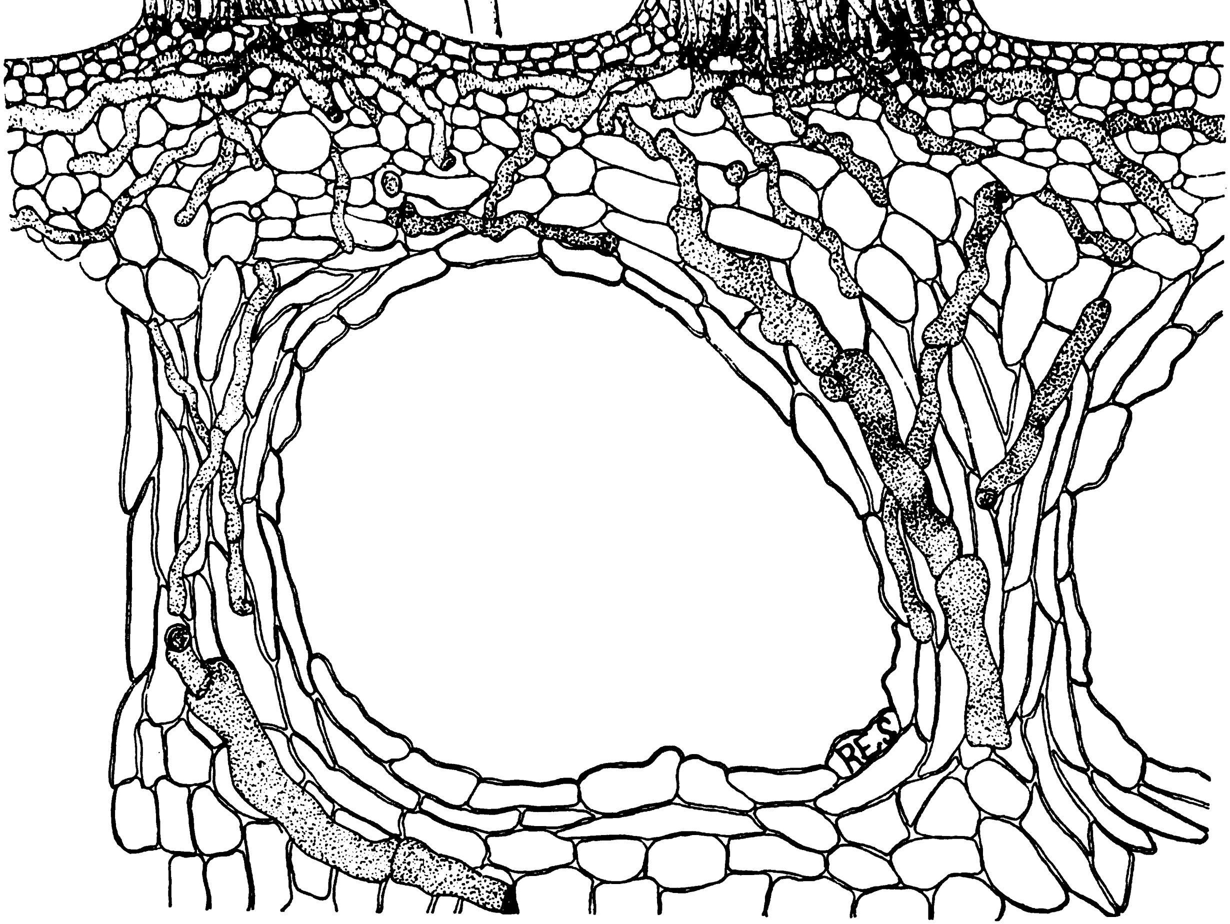


SMITH on "SOFT SPOT" of ORANGES.

de plantes. Ainsi, l'*Anthophora femorata* reste fidèle à l'*Echium vulgare;* l'*Anthophora funcata* compose sa pâtée sur la *Melissa officinalis;* l'*Anthophora mixta* visite exclusivement les differentes espèces de *Stachys*, le *Stachys hirta* surtout." This relates to Europe; in our eastern states Robertson and Patton have recorded similar instances. It must be clearly recognized, however, that in the regions mentioned such instances are exceptional; and, as Müller remarks, if each flower had its own exclusive visitors, the number of visits would not depend upon its conspicuousness as compared with other flowers.

In New Mexico, however, it is very common to find species of bees practically confined to particular species of flowers. The large genus Perdita (80 species are now known) is with few exceptions confined to the arid region, and repeated observation shows that most of the species, at least, are practically confined to one kind of flower. The same may be said to a less extent of arid region species of Heriades, Colletes, Calliopsis, etc., but there are many genera (*e. g.*, Halictus) of which the species range far and wide over the blossoms, as do their representatives in damper climates. It is to be remarked, further, that those flowers which have their special species of Perdita, and therefore might be thought independent of outside help, are many of them extremely conspicuous. Nothing could be more conspicuous than the splendid orange yellow heads of *Baileya multiradiata*, or the beautiful creamy flowers of the species of Mentzelia. One thing, however, may lessen the value of the Perditæ, and that is that they are small, and do not take long flights; it may therefore be advantageous to attract some Melissodes or Megachile, bringing pollen from a distant plant, even when the attendant Perditæ are in profusion.

Another thing which one has to notice is, that the honey bee, now common everywhere, sets aside all rules of bee etiquette. It goes everywhere, flies at all hours of daylight, and revels in flowers which wild bees hold in abhorrence. Therefore, it seems to me, those experiments which have been made with honey bees to determine the action of bees in general are inconclusive. Yesterday evening I passed some bushes of *Datura metelioides*, with a profusion of great white flowers making the air heavy with their odor. The proper visitor of these flowers, a hawk-moth (Phlegethontius), was there, but there were also numerous honey bees, using the flowers as if they were their exclusive property.

There is a yellow flowered Sisymbrium common in the Mesilla

valley, either a form of *S. canescens* or a closely allied species. It comes into flower very early; this year I found the first on January 31. It is visited in February by honey bees, but not by native bees, which are not out so early. Nevertheless, by the end of February it has set numerous pods. This would not call for particular comment but for the fact that by the middle of April, when the native bees are out, it proves to be a most attractive bee plant. That is to say, it is very attractive to bees (mostly Andrenidæ), but can do quite well without them. Persons observing the flowers at different times of the year might thus reach very different conclusions.

It is also true, with some of our flowers, that observations made in different seasons or localities, though at the same time of the year, would yield quite different results. For example, take the cultivated plums in the Mesilla valley, the white flowers of which are very attractive to bees, especially Andrenidæ. On April 9 to 12, 1895, on the farm of the Agricultural Experiment Station, Miss J. E. Casad and the present writer took the following bees from flowers of plum: *Apis mellifica* L., *Osmia prunorum* Ckll., *O. cerasi* Ckll., *Nomada incerta* Cresson, *Synhalonia lycii* Ckll. (ined.), *Podalirius affabilis* Cresson, *Anthidium* sp. (escaped capture), *Prosapis mesillæ* Ckll., *Agapostemon texanus* Cresson, *Halictus*, 2 sp., *Andrena sphecodina* Csd. & Ckll., *A. jessicæ* Ckll., *A. prunorum* Ckll., *A. casadæ* Ckll., *A. nigerrima* Casad. *A. fracta* Csd. & Ckll., *A. electrica* Csd. & Ckll. There were also taken or seen various other insects, including *Danais archippus*, *Pyrameis cardui*, *Colias eurytheme*, *Heliothis armigera*, *Peridroma saucia*, *Evergestis simulatalis* Grote, among the lepidoptera; *Sarcophaga incerta* Walker, *Alophora luctuosa* Bigot (both det. Coquillett), among the diptera, etc. Now this year (1897) I was anxious to obtain further material of several of the above bees, and so watched the plum trees carefully. On March 24, in Mesilla, I caught one ♂ *Andrena fracta;* on April 4 one *Halictus amicus* Ckll. (ined.); on April 15 I saw a *Bombus;* but the species of 1895 were for the most part totally absent! I visited the very same trees at the very same time, and still failed to find the bees. Had a stranger come here to collect, with the account of the 1895 captures before him, surely he would have set me down a liar. It would have seemed incredible that the experience of one year should be so flatly contradicted by that of another.

I have been interested this year in watching in Mesilla our native *Sambucus mexicana*. Müller, writing of *S. nigra*, remarks on the absence

of pollen collecting bees, and the same applies exactly to *S. mexicana.* It is of no account whatever for bees. At the same time, however, it does attract great quantities of small diptera and hymenoptera. One day, in the middle of May, I swept an elder tree in a neighboring orchard, and sent the flies to Mr. Coquillett, and the Hymenoptera to Mr. Ashmead. Here are the names as kindly determined by them:

DIPTERA: *Eugnoriste occidentalis* Coq., *Tachydromia postica* Walk., *Chlorops obesa* Fitch, *Agromyza platyptera* Thom., *Micropeza producta* Walk.

HYMENOPTERA: *Ammoplanus lævis* (Prov., as *Anacrabro*), *Hexaplasta zigzag* Riley, *Microterys marginatus* Ashm. n. sp., *Elasmosoma cockerellii* Ashm. n. sp., *Protapanteles monticola* Ashm., *Meteorus vulgaris* Cress., *Lysiphlebus* sp.

It is to be observed with regard to *Eugnoriste occidentalis*, that it is a mycetophilid with a remarkably long proboscis, so far only known from this vicinity, but very abundant here. It visits all sorts of flowers and must possess some importance to them. It is, perhaps, more especially adapted to the smaller Compositæ, like certain of the meloid beetles.—T. D. A. COCKERELL, *Mesilla, New Mexico.*

THE OFFICIAL NOMENCLATURE OF THE ROYAL BOTANICAL GARDEN AND MUSEUM OF BERLIN.

IN a recent number of *Gartenflora*[1] the staff of the Botanical Garden and Museum of Berlin publishes its code of working rules concerning the formation, choice, and application of plant names. After a brief but forcible introduction, describing the present confusion in nomenclature, the unintelligibility of the names used by certain American botanists, the practical rather than theoretical importance of nomenclature in general, and finally the difficulties of a nomenclature reform from the side of the applied sciences, the conclusion is reached that the course of the extreme reformers cannot be followed. The members of the staff state that they are fully aware that it is impossible to secure a uniform nomenclature, but recognize no harm in the fact that certain variations exist and must remain. For these reasons they do not wish to have their rules regarded as laws to be laid upon other botanists by any authority. However, they cannot

[1] *Op. cit.* **46**: 304. June 1897.

but recommend them earnestly to their colleagues for the establishment of a generally intelligible nomenclature, and particularly one now familiar in the applied branches. Attention is especially called to the close similarity between these rules and those governing the nomenclature of the Kew Index, the only important difference being the priority rule for species. This will affect a difference only in case of species that have been transferred from one genus to another with a concomitant alteration in the specific name, a class not large when compared with all other specific and generic names, upon which there will be practical agreement between the Berlin staff and those of the leading English establishments, not to mention the conservative element in other countries.

The work of the Berlin Garden and its museum needs no encomium. Certainly no other continental institution has in recent years exercised such a wide and lasting influence upon phanerogamic classification. On this account, recommendations emanating from its learned staff are entitled to careful consideration in all parts of the world. The rules may be translated as follows:

1. In the choice of names for the genera and species of plants, the fundamental principle of priority is usually to be maintained. The years 1753-4 are regarded as the point of departure in the determination of priority.

2. A generic name, however, shall be dropped if it has not been in general use during fifty years reckoned from the date of its establishment. Nevertheless, if, in consequence of the *Lois de la nomenclature* of the year 1868, it has been again restored in the preparation of monographs or larger floras, it shall remain current with us.

3. In order to secure uniformity in the group designations of the vegetable kingdom we wish to bring into use the following endings: series shall end in *-ales*, families in *-aceæ*, subfamilies in *-oideæ*, tribes in *-eæ*, subtribes in *-inæ* The endings are added to the stem of the generic name; thus, Pandan(us) -ales; Rumex, Rumic(is)-oideæ; Asclepias, Asclepiad(is)-eæ; Metastelma Metastelmat(is)-inæ; Madi(a)-inæ.[2]

4. Regarding the gender of generic names, we follow in classical designations the correct grammatical usage, while in later names and barbarisms the usage in the *Natürlichen Pflanzenfamilien* holds good. Changes in ending or in other parts of the word ought not as a rule be made. However, notorious errors in designations derived from proper names must be removed;

[2] A few exceptions, such as Coniferæ, Cruciferae, Umbelliferae, Palmae, etc., rightly continue to stand.

e. g., one should write Rülingia for the Rulingia used by the English and introduced with us.

5. Generic names, which have been relegated to synonymy, had better not again be applied in an altered sense to designate new genera or even sections, etc.

6. The choice of specific names shall be determined by priority unless serious objections to its application can be raised by monographers. If a species has been transferred to another genus, it must even there bear the oldest specific name.

7. The author who first named a species, even if it was under another genus, should always be shown, and accordingly his name is to be placed in parenthesis before that of the author who made the transference to the new genus; thus, *Pulsatilla pratensis* (L.) Mill., on account of *Anemone pratensis* L. If an author has himself placed his species in another genus we drop the parenthesis.[3]

8. So far as the manner of writing specific names is concerned, the method followed by Linnaeus has been introduced in the Botanical Garden and Museum. All specific names should be written with small letters, except those derived from personal names and those which are substantives (commonly names of still current or at least formerly recognized genera), *e. g.*, *Ficus indica*, *Circæà lutetiana*, *Brassica Napus*, *Solanum Dulcamara*, *Lythrum Hyssopifolia*, *Isachne Büttneri*, *Sabicea Henningsiana.*

9. If proper names are used in the formation of generic and specific names, we add in case of words ending in a vowel or in *r*, only *a* (for the genus) or *i* (for the species), thus Glazioua (from Glaziou), Bureaua (from Bureau), Schützea (from Schütze), Kernera (from Kerner), and Glazioui, Bureaui, Schützei, Kerneri. In case the name ends in *a*, we change this vowel for the sake of euphony to *ae*, thus from Colla comes Collaea. In all other cases *ia*, or *ii* is appended to the names, thus Schützia (from Schütz), Schützii, etc. This holds also of names ending in *us*, thus Magnusia, Magnusii (not Magni), Hieronymusia, Hieronymusii (not Hieronymi). The adjectival forms of proper names are framed in a corresponding manner, *e.g.*, Schützeana, Schütziana, Magnusiana. A distinction in the application of the genitive and adjectival forms is not at the present time practicable.

10. In the formation of compound Latin and Greek nouns or adjectives the vowel between the stems is a connecting vowel, being in Latin *i*, in Greek *o*. Thus, one should write *menthifolia*, not *menthæfolia.* (Here it is not the genitive of the former stem which enters into combination.)

11. We recommend the avoidance of such combinations of names as involve tautology, *e. g.*, *Linaria Linaria* or *Elvasia elvasioides*. Similarly it is per-

[3] The authors engaged in continuing works in which the parenthesis is not used do not regard themselves bound by this rule.

missible to depart from priority in cases of names which have clearly arisen through gross geographic errors on the part of their authors, as for instance, *Asclepias syriaca* L. (which comes from the United States), and *Leptopetalum mexicanum* Hook et Arn. (from the Liu-Kiu Islands.)

12. Hybrids are designated by the names of the parents directly connected by the sign ×, the alphabetical order of the specific names being maintained, *e. g.*, *Cirsium palustre* × *rivulare*. In the position of the names no distinction is made as to which was the father and which the mother plant. To hybrids we consider the binomial nomenclature unsuited.

13. Manuscript names have no right under any circumstances to consideration on the part of other authors, not even when such names appear upon the printed labels of *exsiccati*. The same thing holds in the case of horticultural names or designations in trade catalogues. The recognition of species presupposes a printed diagnosis, which it is true may occur even upon a label of *exsiccati*.

14. An author has no right to alter at will a once published generic or specific name, unless moved to do so by very weighty reasons, such as those in Rule 11.

Signed by A. Engler, I. Urban, A. Garcke, K. Schumann, G. Hieronymus, P. Hennings, M. Gürke, U. Dammer, G. Lindau, E. Gilg, H. Harms, P. Graebner, G. Volkens, L. Diels.

B. L. ROBINSON, *Cambridge, Mass.*

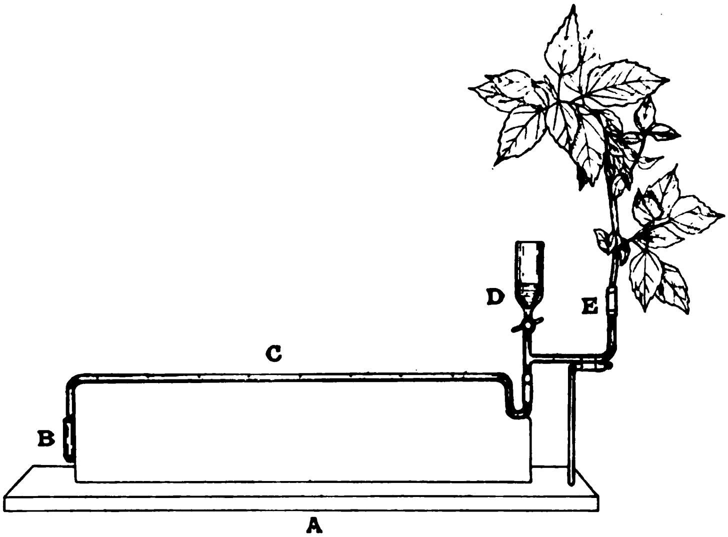
A CONVENIENT POTOMETER.

THE most satisfactory method for the demonstration and exact measurement of the amount of water taken up by transpiring plants or by branches is by the use of the potometer. The simplest form is that used by Darwin and Phillips.[1] Practical instruments have been described by Kohl, Detmer, and others. A modification of Kohl's apparatus, designed in this laboratory, has been found to meet all the requirements of exact measurement, and at the same time is useful in demonstration in the lecture room, where its operations may be witnessed by a class of eighty or one hundred without difficulty. For the latter purpose the apparatus is always ready for use and may be fitted with a plant in five minutes.

The apparatus consists essentially of a horizontal tube of 1^{mm} internal diameter, calibrated into portions containing 100^{mg} of water. At

[1] DARWIN, Physiology of Plants, 73. 1894.

one end a portion 10^{cm} in length is bent downward, and at the other end a portion 20^{cm} in length is bent into U form. To the U-shaped portion is fitted a three-way tube by means of rubber tubing. To one arm of the three-way tube is fitted a shoot, by means of rubber tubing, which should be wired for safety. An entire plant may be used if a



A convenient potometer.—*A*, base; *B*, reservoir for water; *C*, calibrated tube; *D*, separatory funnel for water supply; *E*, fitting of plant and tube.

suitable fitting is used, such as a straight chloride of calcium tube with the plant sealed in by means of moulding clay. The free end of the three-way tube terminates in a separatory funnel.

To determine the amount of water used by a shoot proceed as follows: Place a plant in a reservoir of water, or if a branch only is to be used bend the shoot in such manner that the point of incision is under the surface. Cut off obliquely under water, and fit a section of heavy rubber tubing of the proper size, 5^{cm} in length, to the end of the shoot. For safety the joint should be wired. The fitting should be done under water. Fill the funnel and allow the entire system of tubes to become filled with water free from air bubbles. Also fill the vessel under the end of the tube. Now lift the branch from the water, keeping the rubber tube filled and fit to the tube in such manner as to

exclude air. If the admission of air is unavoidable invert the apparatus and allow it to collect under the funnel.

After the plant has been allowed to stand for a few minutes observations may be begun.

Remove the cylinder of water at *C* and allow a bubble of air, 5^{mm} long, to enter the tube, then replace. Note the exact time necessary for the bubble of air to traverse the calibrated portion of the tube as well as its separate divisions. When the bubble passes the calibrated portion of the tube open the stopcock and drive the bubble beyond the zero-point. The observation can then be repeated.

The conditions of transpiration of the shoot may be controlled by means of a bell glass and by regulation of the temperature, light, etc. The collection of small air bubbles in the tube which are picked up by the moving bubble may be avoided by the use of freshly boiled water allowed to cool in a closed vessel. The increase in the size of the moving bubble would, of course, be a source of error. The use of a horizontal calibrated tube avoids sources of error found in vertical tubes.

For demonstration in the lecture room replace the cylinder of water with one of aniline dye after a bubble has been allowed to enter the tube, and use the end of the colored column as an indicator. A time piece and thermometer may be conveniently placed upon the support as shown in the illustration.

The various precautions necessary to secure normal transpiration data must, of course, be observed. Thus, branches in which negative pressure exists must be allowed to stand in water several hours previous to use. This is illustrated by the following experience. A leafy shoot of fuchsia in which a negative pressure existed was cut off under water at 12:45 P.M. and fastened to the apparatus at 1 P.M. After a few minutes the following observations were made:

1:27	P.M.	Indicator	bubble	at	0^{mg}.	Temp.	21.0°C.
1:50	"	"	"	"	300	"	21.0
2:05	"	"	"	"	500	"	21.0
2:14	"	"	"	"	600	"	21.0
Readjusted.							
2:17	"	"	"	"	0	"	20.8
2:28	"	"	"	"	100	"	20.7
2:40	"	"	"	"	200	"	20.5
2:57	"	"	"	"	300	"	20.0

This shoot was taken from the apparatus and placed in water. The following morning a small portion was cut from the excised end, and it was refitted to the apparatus with the following results, which show that the negative pressure had been equalized during the first day:

8:09	A.M.	Indicator	bubble	at	0^{mg}.	Temp.	18.0°C.
8:26	"	"	"	"	100	"	18.0
8:43	"	"	"	"	200	"	18.5
8:45:5	"	"	"	"	300	"	18.5
9:15:5	"	"	"	"	400	"	19.0
9:31	"	"	"	"	500	"	19.0
9:45	"	"	"	"	600	"	19.5
Readjusted.							
9:48	"	"	"	"	0	"	19.5
10:02	"	"	"	"	100	"	19.0
10:17	"	"	"	"	200	"	19.0
10:32	"	"	"	"	300	"	19.1
10:44	"	"	"	"	400	"	19.5
10:57:5	"	"	"	"	500	"	20.0
11:12	"	"	"	"	600	"	20.0
Readjusted.							
11:13:5	"	"	"	"	0	"	20.0
11:26	"	"	"	"	100	"	20.0
11:39	"	"	"	"	200	"	20.1
11:53	"	"	"	"	300	"	20.4
12:05:5	"	"	"	"	400	"	20.7
12:20	"	"	"	"	500	"	21.0
12:33	"	"	"	"	600	"	21.0
Readjusted.							
12:35	P.M.	"	"	"	0	"	21.0
1:40	"	"	"	"	500	"	22.0
1:52:5	"	"	"	"	600	"	22.0
Readjusted.							
1:54	"	"	"	"	0	"	22.0
2:07	"	"	"	"	100	"	22.0
2:20	"	"	"	"	200	"	22.0
2:33	"	"	"	"	300	"	22.0
2:46	"	"	"	"	400	"	22.0
2:58:5	"	"	"	"	500	"	22.0
3:11:5	"	"	"	"	600	"	21.6
Readjusted.							
3:13	"	"	"	"	0	"	21.6

3:25:5	P.M.	Indicator	bubble	at	100mg.	Temp.	21.5°C.
3:39:5	"	"	"	"	200	"	20.8
Readjusted.							
3:41	"	"	"	"	0	"	20.8
4.58	"	"	"	"	500	"	19.2 C

Net duration of experiment, 8 hours and 38 minutes; total amount of water used, 3.7 grams. The irregular variations in the forenoon were due to gusts of wind and the repeated opening of the doors.

The leaves showed a superficial extension of 300 sq cm, including the petioles; area of stem surfaces, 40 sq cm. April 16 the leaves were stripped from the shoot, the base of which was trimmed and refitted to the apparatus, and the following observations were made:

10:31	A.M.	Indicator	bubble	at	0mg.	Tem.	17.5° C.
11:12	"	"	"	"	100	"	18.0
11:43	"	"	"	"	200	"	18.8
12:13	P.M.	"	"	"	300	"	17.5
1:23	"	"	"	"	500	"	16.0
2:00	"	"	"	"	600	"	15.1

The data given above demonstrate the value and accuracy of this method of observation.

Valuable data of the transpiration of winter branches and buds, and opening leaf and flower buds have also been obtained by the use of this instrument.

The apparatus was constructed and calibrated by the mechanics whose services are available to the department.—D. T. MacDougal, *University of Minnesota.*

PARTHENOGENESIS IN MARSILIA.

In February 1896 the writer was led to suspect that some prothallia of *Marsilia Drummondii* which had been grown in the laboratory had developed embryos of considerable size without fertilization having been accomplished in every case. In order to determine whether this was possible, and if so to what size the sporophytes would develop, macrospores were isolated from the microspores before the antheridia matured. Spores were sown on February 13 and February 20. At each time two sporocarps were used. Each was cut on one side to admit water more rapidly, and placed in distilled water in a separate dish. In an hour or two all the sporangia were expelled from the

sporocarps. Within three or four hours after sowing, several macrospores were taken from each lot and passed separately under the microscope to insure that no microspores accompanied them. For this purpose a Leitz objective no. 3 and eyepiece no. 1 were used. The macrospores thus isolated were placed in distilled water in shallow watch glasses and left standing beside the vessels containing the macrospores which were still mixed with microspores.

The spermatozoids matured and were set free about eighteen hours after sowing, and when the specimens were examined twenty-one hours after sowing all the spermatozoids had been discharged. The archegonia on spores from the first and second sporocarps were counted at the end of one day, and the embryos in the same lots were counted and measured at the end of seven days. From the third and fourth sporocarps the embryos were counted at the end of four days. The following tables show the number of spores from which embryos were obtained, the number of spores which produced prothallia but no embryos, and the number which did not develop at all:

Spores from sporocarp I.

With spermatozoids				Isolated macrospores			
1 day		7 days		1 day		7 days	
Archegonia	14	Embryos	20	Archegonia	14	Embryos	11
		Sterile prothallia	9			Sterile prothallia	3
Sterile spore	1	Sterile spores	7	Sterile spore	1	Sterile spore	1
	15		36		15		15

Spores from sporocarp II.

With spermatozoids				Isolated macrospores			
1 day		7 days		1 day		7 days	
Archegonia	5	Embryos	22	Archegonia	12	Embryos	6
		Sterile prothallia	16			Sterile prothallia	6
Sterile spores	5	Sterile spores	27	Sterile spores	3	Sterile spores	3
	10		65		15		15

SPORES FROM SPOROCARP III, AFTER FOUR DAYS.

With spermatozoids		Isolated macrospores			
		Lot *a*	Lot *b*	Lot *c*	Total
Embryos	8	2	3	5	10
Sterile prothallia	6	5	1	4	10
Sterile spores	21	3	6	1	10
	35	10	10	10	30

SPORES FROM SPOROCARP IV, AFTER FOUR DAYS.

With spermatozoids		Isolated macrospores		
		Lot *a*	Lot *b*	Total
Embryos	19	4	2	6
Sterile prothallia	1	4	6	10
Sterile spores	11	3	2	5
	31	11	10	21

Comparing the prothallia that produced embryos with those that were sterile we find:

	Embryos	Sterile	Total	Per cent. fertile
Sown with microspores	69	32	101	69
Isolated from microspores	33	29	62	53

Briefly stated, over 50 per cent. of the isolated female prothallia produced embryos, while not more than 69 per cent. of those which were mixed with male prothallia produced embryos.

In both cases, at the end of seven days the embryos were of three sorts: (1) those with the root and the cotyledon about equal in length; (2) those with the root less than one-third the length of the cotyledon; and (3) those with no root developed. Those of the first sort from the isolated spores were 10–12^{mm} long, while those of the same sort from the mixed spores were 8–13^{mm} long. Those of the second sort from the isolated and the mixed spores were 4–9^{mm} and 7–9^{mm}, respectively. The embryos of the third sort were 3–7^{mm} long from the

isolated, and 4–6^{mm} long from the mixed spores. The embryos from the mixed spores were slightly larger than the others, and had straighter, whiter roots. The roots of the others turned brown after a time and became crooked and shrunken. The plants were transferred to moist soil in an earthenware saucer, but they did not receive much attention and did not long continue to develop. A few experiments were attempted with other sporocarps, but the material, which had been sent to America from Australia by the Baron von Müller and bore no date, seemed either to be too old or to have dried too young, for most of the spores failed to germinate.

Parthenogenesis, *i. e.*, the development of an unfertilized egg-cell into a plant, has long been known in *Chara crinita*, where it was early observed by De Bary.[1] Lately Klebs[2] has given an account of the germination of the gametes of Ulothrix, Protosiphon, and Spirogyra under certain circumstances without conjugation. The apogamous formation of the cystocarp described by Davis[3] for Batrachospermum and Ptilota is another addition to the allied physiological facts. In none of the higher plants has parthenogenesis been known,[4] though the well known occurrence of apogamy in some of the ferns makes it not surprising to meet with parthenogenesis in this group. If, as the writer's experiments seem to indicate, we really have in Marsilia another example of parthenogenesis, then this plant may afford the cytologist useful material for the study of nuclei in embryos which are developed in this way.—WALTER R. SHAW, *Stanford University.*

[1] GOEBEL, Outlines of class. and spec. morphology of plants. Eng. Trans. 64. 1875.—DE BARY, Zur Keimungsgeschichte der Characeen. Bot. Zeit. 379. 1875.—ALEX. BRAUN, Ueber Parthenogenesis bei Pflanzen. Abhandl. der Akad d. Wiss. zu Berlin 337. 1856.

[2] KLEBS, Die Bedingungen der Fortpflanzung bei inigen Algen und Pilzen 210, 230, 313. 1896.—STRASBURGER, Ueber Befruchtung. Jahrb. f. wiss. Botanik **30**:408. 1897.

[3] DAVIS, The Fertilization of Batrachospermum. Ann. Bot. **10**:49–76. 1896. —Development of the procarp and cystocarp in the genus Ptilota. BOT. GAZ. **22**: 353–378. 1896.

[3] STRASBURGER, Schwärmsporen, Gameten, pflanzliche Spermatazoiden und das Wesen der Befruchtung. Hist. Beit. **4**: 155. 1892.—STRASBURGR, NOLL, SCHENK, und SCHIMPER, Lehrbuch der Botanik 58, 243, 291. 1894.—STRASBURGER, Ueber Befruchtung. Jahrb. f. wiss. Bot. **30**: 422. 1897.

CURRENT LITERATURE.

BOOK REVIEWS.

The fertility of the land.

IN the volume of the Rural Science Series bearing the above title[1] there is placed in permanent form the observations, the experience, and the convictions of a man of mature years, of rare good judgment, and of wide intimate personal contact with the subjects and objects of the whole text. A man of clear thinking, pleasing expression, and warm sympathies, who winnows his grain clean, has given to those who will read it an extremely instructive and intensely practical book.

The title chosen for the volume is such as to permit the author to present his views regarding the practical details of a wide range of farm problems, and to use a large share of the results of his own studies, and of those of others bearing upon them.

The subjects treated are set forth under fifteen chapters: an inventory of the land; the evolution of the plow; tillage and the land; conservation of moisture; irrigation and drainage; farm manures; manures produced by various animals; the waste of manures; the care, preservation, and application of manure; nitrogen and nitrification; the phosphoric acid and potash supply; commercial fertilizers; lime and various amendments; green manures and fallows; rotations. Then follows an appendix of thirty pages presenting the fertilizing constituents of agricultural and other products, compiled from various sources, in which the water, ash, nitrogen, phosphoric acid and potash are given in pounds per thousand pounds of the substance. A full index and detailed table of contents make the subject matter of the book contained in the 403 pages easily accessible.

It will be evident from the foregoing that the book has in it much of value and interest for the plant physiologist as well as for the plant culturist.

The thoughts which are presented in the first few pages, where the author has "a chat with the young farmer," are extremely wholesome, and introduce the reader to the man in such a way that he is assured of good things to follow.

The book is intended for those who think, and it is one which will appeal

[1] ROBERTS, ISAAC P.:—The fertility of the land, a summary sketch of the relationship of farm practice to the maintaining and increasing the productivity of the soil. 12mo, pp. 440, illustrated. New York: The Macmillan Co., 1897. $1.25.

strongly to intelligent farmers; but like all good books upon farm management, it must be read, as the writer has evidently intended it should be, with the understanding that while the statements are the fixed or tentative convictions of the author, they are not to be looked upon as axiomatic and received as unhesitatingly as the assertion that twice two make four. As a single instance in point, among many, where the importance and great value of frequent tillage is being discussed, the writer says (page 222):

During this year, as in the previous one, the vines remained fairly green until October 9, when they were killed by frost. There were no marked signs during the summer or fall of arrested growth and development due to lack of nitrogen or moisture. The rainfall during the six months from April to October 1895 and 1896, was as follows:

	1895	1896	Average rainfal for sixteen years prior to 1895
	Inches	Inches	Inches
April	1.47	1.02	2.27
May	3.60	2.64	4.23
June	3.37	4.36	3.69
July	1.96	3.69	3.88
August	4.12	2.43	3.30
September	2.03	3.84	2.94
	16.55	17.98	20.31

This table shows a deficiency of rainfall for six months in 1895, as compared with the average for sixteen years, of 3.76 inches, and in 1896 of 2.33 inches.

Other equally striking experiments could be cited to show the marked effect produced by frequent and superior tillage in securing available nitrogen and in conserving moisture, but those given will suffice to call attention to the means which may be successfully used to furnish nitrogen and other necessary plant-food and moisture, continuously to the growing plant. True, frequent inter-tillage benefits potatoes more than most other plants, since the earth-mulch, in addition to the beneficial effect already noted, serves to keep the soil cool, a condition which is highly beneficial to the potato in most localities. This earth-mulch was kept up until late in the season, and seemed to be quite as beneficial in the late as in the early part of the season, although it was not so perfect, since the cultivators had to be narrowed up that the partly grown tubers might not be disturbed.

From these and other similar experiments we are irresistibly led to the conclusion that the meager crops so universally secured are usually not due so much to the lack of rainfall and potential nitrogen and other elements of plant growth in the soil as to lack of ability or knowledge to make them available. Here, again, we arrive at the point where a choice must be made between utilizing the plant food and moisture already in the soil or securing the one by purchase and the other by expensive irrigation.

In this connection attention should be called to the fact that in the cases cited by the author the rainfall of August and September is fully up to the average for the sixteen years quoted, and that these are the critical months which determine what the yield of the potato crop shall be; hence it is possible that the results obtained were due quite as much to the rainfall of the two months cited as to the frequent inter-tillage which the crop received, and which is looked upon as the chief factor in securing the large yield. These suggestions are made not in the spirit of adverse criticism, but simply to call attention to the manner in which this and all similar books should be read.—F. H. KING.

The Illustrated Flora.[2]

THAT the second volume of this important work should follow after the first at an interval of less than a year is a matter of surprise to many familiar with the usual delays in the preparation of such extensive works. To those who know Dr. Britton, however, this evidence of rapid and continuous work is no great surprise. The families treated in the present volume are of more general interest than those presented in the first, and give a better exemplification of the principles controlling the work. These principles need no further mention than that made in our review of the first volume. The sequence of families, that of Engler, certainly commends itself still more as a rational one when applied to our own familiar groups, and there should be no hesitation in using it. The general principles of the nomenclature adopted have already received the sanction of the GAZETTE. From our standpoint, however, the most serious changes in the nomenclature of the book arise not from the application of certain rules of nomenclature, but from the extreme views as to generic limitations. We are willing to grant that we have been entirely too conservative in holding together very distinct groups of species under a single genus, and this movement toward the breaking up of our polymorphic genera commends itself to our judgment. Such breaking up, however, may be carried to such an extreme that a genus will entrench too closely upon our conception of a species. We still believe that there is room for such a taxonomic group as a subgenus. This is so largely a matter of individual judgment, however, and affects so little the usefulness of the book under consideration, that it needs no further mention.

So much has been published recently upon our northeastern flora in a scattered way, that probably the greatest value of the book to the professional taxonomist is to have all this new material organized in systematic fashion,

[2] BRITTON, NATHANIEL LORD, and BROWN, HON. ADDISON. An illustrated flora of the northern United States, Canada, and the British possessions, etc. Volume II. Pp. 643. Portulacaceæ to Menyanthaceæ. New York: Charles Scribner's Sons, 1897. $3.00.

so that he can get it all together and not incur the danger of missing it in his researches.

A word must be said in reference to the illustrations, chiefly because they have received some unfavorable comment. The GAZETTE has not been trained to believe in poor illustrations, but it also recognizes the limitations in these matters. Very numerous small cuts, printed with the text, are not to be criticised from the standpoint of lithographic plates. In our judgment, the cuts in this book serve their purpose admirably. They are convenient in position and in most cases are fully suggestive. It is a wonder that such an amount of illustration can be possible in a book of such low price. In looking over certain groups with which we are somewhat familiar, we can appreciate the suggestiveness of the cuts, as giving definite representations of statements in the text that may not give a clear impression.

Another volume, containing the rest of the Sympetalae, will complete the work.—J. M. C.

The Synoptical Flora.[3]

THE prompt appearance of another fascicle of the polypetalous orders of this great work is a gratification to students of American botany. In 1878 and 1884 the two parts including all the gamopetalous orders were issued. These parts were reissued in 1886 by the Smithsonian Institution, making a volume of nearly 1000 pages. After the death of Dr. Gray the work was carried on by Dr. Sereno Watson, and then by his successor, Dr. B. L. Robinson. Under Dr. Robinson's editorship the first fascicle of Polypetalæ (Ranunculaceæ to Frankeniaceæ) was issued in 1895, containing much that was left in manuscript by Drs. Gray and Watson. The present fascicle also contains work left in manuscript by Dr. Gray (portions of Portulacaceæ, Elatinaceæ, Ternstrœmiaceæ, Cheiranthodendreæ, most of Malvaceæ, Sterculiaceæ, Tiliaceæ, Malpighiaceæ, Zygophyllaceæ, most of Rutaceæ, Simarubaceæ, Burseraceæ, Anacardiaceæ, Meliaceæ, Cyrillaceæ, and Olacineæ). Linaceæ, Geraniaceæ, Aquifoliacæ, Celastraceæ, and Rhamnaceæ are presented by Dr. Trelease; Vitaceæ by Professor Bailey; and Hypericaceæ by Dr. Coulter. In addition to the great burden of editing, Caryophyllaceæ, Ficoideæ, Tamariscineæ, Sapindaceæ and Polygalaceæ fell to Dr. Robinson, besides certain genera in some of the families presented by Dr. Gray.

The general spirit of this work is sufficiently well known to need no fur-

[3] GRAY, ASA.—Synoptical Flora of North America. Vol. I. Part I. Fascicle 2. Caryophyllaceæ to Polygalaceæ. Continued and edited by BENJAMIN LINCOLN ROBINSON, with the collaboration of William Trelease, John Merle Coulter, and Liberty Hyde Bailey. Pp. 207–506. New York, Cincinnati, and Chicago: American Book Company. Cambridge, Mass.: Cambridge Botanical Supply Company. London: William Wesley & Son. Leipsic: Oswald Weigel. $2.60.

ther statement. It is becoming increasingly evident, however, that the continuation of the *Synoptical Flora* could not have fallen into more competent hands. The most scrupulous care is evident upon every page of Dr. Robinson's work. While critical enough not to accept everything published, he has evidently taken all possible pains to consider every claim, and under his editorship the *Synoptical Flora* cannot be accused of the neglect which comes from carelessness. Judgment must always differ as to the taxonomic importance of certain characters, and the conception of variety, species, etc., is a variable one. Naturally, a work prepared by several authors, however carefully edited, will be more or less uneven, but this is inevitable, and it would seem that its possible disadvantage is far outweighed by the positive advantage of more rapid publication.

Perhaps the most important pieces of fresh work are found in Dr. Robinson's revision of the Caryophyllaceæ, and Professor Bailey's treatment of the Vitaceæ.

A supplement of fifteen pages contains "additions and corrections" in connection with the first fascicle, so far as the editor has had time to consider carefully the fresh literature on the groups presented. It is announced that a third fascicle is now in preparation by Dr. Robinson to include the Leguminosæ.—J. M. C.

Plantæ Europææ.[4]

It is a gratification to know that Richter's "Enumeratio" is to be completed, and by so competent an editor as Dr. Gürke, curator of the Botanical Museum of Berlin. The first volume of Richter's work was published seven years ago, and at his death it seemed very doubtful whether it would ever be completed. The second volume was left in manuscript, but the accessions have been so numerous, and matters of range, synonomy, and nomenclature have become so modified that Dr. Gürke has been called upon to do a large amount of editing. He has concluded, also, to issue the second volume in fascicles, the first one of which is now before us. It is not necessary to explain the scope and importance of this work. Its purpose is fully stated in the title, and its quality is well known from the first volume. The present author adopts the sequence of Engler in *Natürlichen Pflanzenfamilien*, and in matters of nomenclature he is of the Berlin school, which accepts the 1753 date and the law of priority, but thinks that the latter must not be too rigidly applied. The present fascicle introduces the Archichlamydeæ, extending from Juglandaceæ through Chenopodiaceæ.—J. M. C.

[4] GÜRKE, DR. M.—Plantæ Europææ. Enumeratio systematica et synonymica plantarum phanerogamicarum in Europa sponte crescentium vel mere inquilinarum. Operis a Dr. K. Richter incepti. Tomus II. Fasc. 1. 8vo. pp. vi + 160. Leipzig: Wilhelm Engelmann, 1897. *M.* 5.

Chapman's Flora.[5]

THE name of Dr. Chapman has been closely associated with the flora of our southern states for three quarters of a century, a record of botanical activity that is almost without parallel. The new edition of his manual is printed from new plates, and the two supplements of the second edition have been incorporated in the body of the work. The conditions under which the author has been compelled to work have prevented the introduction of many changes that would naturally be expected in a new edition. The present volume is essentially the same that the others have been, and this fact of course makes it seem very conservative. It is hardly to be expected that matters of nomenclature and citation could have received critical attention, as they would have involved an amount of labor that the venerable author could not afford. But it is a distinct disappointment that the many new forms recently described by others from the region of the manual have not been sifted and included. It is a good thing to bring material together, and that is the chief purpose of a manual as distinct from a monograph. This omission will work to the disadvantage of the ordinary collector and student of the southern flora who does not have access to the scattered descriptions contained in periodical publications.

However, Dr. Chapman's manual still remains the only manual of this region, and is certainly indispensable. Botanists have a deep feeling of gratitude to the venerable author who has laid them under obligation for so many years.—J. M. C.

The principles of fruit growing.[6]

THIS is the comprehensive title of the last issued volume of the "Rural Science Series." It is a book of over 500 pages, written by the editor of the series, Professor L. H. Bailey. It is well for the credit and long continued usefulness of this work that it was not attempted ten years ago when the author was younger in experience and lacked the busy years during which he has been in touch with the thinking, reading, and practical fruit growers across the continent.

The book is in no sense a descriptive fruit book, with some practical instructions on propagation and orchard management, but, as its title indicates, states the general principles which underlie all fruit culture. It is a masterly joining of science with practice, under varied conditions of soil and climate in the United States and Canada. Varieties are not discussed except in the way of illustrating principles involved in the varied discussions. The

[5] CHAPMAN, A. W.—Flora of the Southern United States. Third edition. 8vo. pp. xxxix + 665. Cambridge, Mass.: Cambridge Botanical Supply Company. 1897. $4.00

[6] BAILEY, L. H., The principles of fruit growing. 12mo. Pp. xii + 508. Figs. 114. New York: Macmillan Co., 1897. $1.25.

different countries of Europe have books of this character, but up to the present our literature on the science and art of fruit growing has been scattered in horticultural reports and papers, and the bulletins of our experiment stations. In this book they are collected and added to from the personal experiences and observations of the author, joined with comparison of views made possible by contact with successful growers and managers.

In our relatively new country we have not yet reached final conclusions as to the exact climatic adaptation of varieties and species to special conditions of soil and air referred to by Professor Bailey under the head of "determinants," as has been done in most parts of Europe. But remarkable advances have recently been made in all divisions of the work of fruit growing, adaptation to markets, etc., and this work covers the ground so completely that even western growers find little room for criticism. Every page will furnish food for thought to the amateur and commercial grower on such topics as spraying, selection of orchard sites, winter evaporation of trees, soil adaptation to varieties, commercial outlook of fruit growing, fruit packing in its details, retardation of bloom, orchard wind breaks, air drainage and soil drainage, influence of frost and water, the stored food of varieties as affected by climate, effects of mulching, laying down tender trees, tillage of fruit lands, conservation of moisture, fertilization of orchard and nursery, the uses of nitrogen in orchards, soils, potash for fruit, alternating varieties for fertilization of blossoms, shading of tree stems in open exposure, and many other topics coming up each day in the individual experience. Besides its use to the actual fruit grower, it is really a book which can be used to the advantage of the prospective fruit growers in the horticultural class rooms of our agricultural colleges.—J. L. BUDD.

A few familiar flowers.[7]

UNDER the above title a new book of suggestions for teachers of small children has appeared. In these days of that chaotic subject known as "nature study" such books are eagerly sought by the poorly trained teacher, and most of them are poorly trained for "nature study." How to interest little people in plants, to teach them to observe wisely, and at the same time to keep well within the limits of knowledge, is a very serious problem. A sort of speculation is usually indulged in which is exceedingly unsafe, and which results in notions that are difficult to banish. The whole truth cannot be told, and it is difficult sometimes to tell a partial truth without, in effect, contradicting the larger truth. It is probably true that the professional botanist is apt to be captious in his criticism of all such attempts, and that he loses sight of the larger end in view.

[7] MORLEY, MARGARET WARNER.—A few familiar flowers; how to love them at home or in school. 8vo. pp. xiv + 274. Boston: Ginn & Company, 1897. 70 cents

In the book before us, which is designed for teachers, the author has selected for study the morning glory, the "nasturtium" [Tropæolum], the "jewel weed" [Impatiens], the scarlet geranium, and the hyacinth. The purpose is to use these plants as indicative of the problems that flowering plants suggest, and the spirit of the work is of the best. There is constant insistence that the plants are to be regarded as living things, engaged in a variety of very interesting work. The usual pedantic terminology, that has so long made the school study of flowering plants an exercise in definition of technical terms, is in the main suppressed, and certainly is never obtrusive. Suggestive comparisons abound, by which interest may be sustained and structures understood. The book will certainly prove very useful to the teachers it is intended to serve; but is it not possible to make such work clear and attractive to children without obscuring the facts? For example, when we are told that "if a pollen grain can join an ovule, both of them will live and form a seed; but if the pollen grain cannot join an ovule both must die," there may be a sense in which this is true, but the real impression apt to be left will be far enough from the truth. And the truth finds not much clearer expression in the statement, "Once on the pistil, the substance of the pollen grain passes down through the style to the ovary, where it unites with an ovule, thus giving it, as we may say, extra vitality." Of course the sexuality of the stamens and pistils is strongly brought out, and much made of it. We cannot expect the actual non-sexual nature of these organs to be made clear to children, but there would seem to be no necessity for so persistently impressing an idea which must later be abandoned. The reader of the book would judge, moreover, that all plants do the work of photosyntax, and the statement is made that "it is the chlorophyll which does the eating for the plant." In this same connection it is perhaps interesting to note, in a summary on the green part of the leaf, that "carbon dioxide is injurious to animal life, while oxygen is necessary to it; hence men and all animals are dependent upon the plant life for the air they breathe, and consequently for their existence. But, on the other hand, animals breathe out carbon dioxide, which the plant needs as food; hence the plant is dependent upon the animals for its existence." These quotations are taken quite at random, but they will serve to illustrate that dangerous tendency to philosophical speculation which, in the absence of a full knowledge of the facts, is never safe. Is it not possible to interest children by banishing speculation and sticking to the facts? We believe that it is.—J. M. C.

MINOR NOTICES.

PROFESSOR F. LAMSON SCRIBNER has issued, as Bulletin no. 7 of the Division of Agrostology, a book of illustrations entitled *American Grasses*. The author has had in preparation for some time a *Handbook of North*

merican Grasses, in which all the North American species are to be figured, but as it will be some time before the remaining figures can be engraved, he has now published three hundred of those now completed. A useful introduction clearly characterizes the family and the tribes in the light of the most recent studies. Each page is occupied by the illustration of a single species, below which a brief description is printed, just such a description as would occur in a manual, with habitat, range, necessary synonymy, etc. The 300 species presented represent 98 genera, and all of the 12 tribes occurring in the United States excepting Bambuseæ. Professor Scribner's drawings are well known for their excellence, and the bulletin will certainly be very valuable to students of grasses.—J. M. C.

IT SEEMS STRANGE to open a manual bearing the date of 1897, and to discover that the plants are arranged according to the Linnæan system. This is true, however, of the *Excursionsflora*[8] of Dr. Karl Fritsch; and why is not the plan an excellent one when facility in finding a name is the only end in view? It has long seemed to us that editions of field manuals and herbarium manuals with Linnæan keys might be very useful. In the vast majority of cases a manual is consulted to discover a specific description, and the most rapid way of discovering the description is a thing to be desired. Besides, most of our manual keys are already artificial. It is not certain, therefore, that the manual before us is to be regarded as an "ancient type," but rather a genuine modern type, which recognizes the real thing sought and then selects the quickest way of getting it.—J. M. C.

MR. F. V. COVILLE has published some notes[9] upon the plants used by the Klamath Indians of Oregon. In the list given there are a few plants which give a suggestion of usefulness in our own arts and industries. Among these may be mentioned the yellow pine lichen, which produces a beautiful canary yellow dye; the Rocky mountain flax, which furnishes a strong fine fiber; and several of the tuberous rooted perennials of the parsley family, which make palatable and nutritious food.

MR. THOMAS HOWELL has begun the publication of a new American flora[10] covering a region that has not been provided with a manual. The area is defined as "north of California, west of Utah, and south of British Columbia," which means that it is chiefly a flora of Washington, Oregon, and

[8] FRITSCH, DR. KARL.—Excursionsflora für Oesterreich (mit Ausschluss von Salisien, Bukowina und Dalmatien). Mit theilweiser Benützung des "Botanischen Excursionsbuches" von G. Lorinser. Small 8vo. pp. lxxii + 664. Wien: Carl Gerold's Sohn, 1897.

[9] Contrib. Nat. Herb. 5:87–108. 1897.

[10] HOWELL, THOMAS.—A flora of northwest America. Vol. I. Fasc. 1 [Ranunculaceæ to Rhamnaceæ]. 8vo. pp. 112. Portland, Oregon: The author. 50 cents.

Idaho. There was certainly need for such a manual, and Mr. Howell is very familiar with the plants of the region. Very modestly he describes the work as a compilation, which manuals almost of necessity are. There is no escape from this compilation when such an extensive range of plants is to be included, even though it results in perpetuating countless errors. Mr. Howell's experience, however, has enabled him to inject a large amount of personal observation into the work, and, what is best of all, field observation. He takes a somewhat radical position in reference to varieties, observing "that if a plant is sufficiently distinct from others to deserve a name it is better to have it described as a distinct species than as a variety of some other species." Accordingly, nearly all of the published varieties of the region have been raised to specific rank. The book cannot help but be a very useful addition to our local floras, and certainly of great service to those in the northwest who are interested in their native plants.—J. M. C.

A THIRD FASCICLE of the enumeration of the flora of Costa Rica has appeared.[11] A second enumeration of the lichens is made by Dr. J. Müller, containing 281 species, 60 of which are new. A second paper on the mosses, by Renauld and Cardot, contains 62 species, 25 of which are new, *Pirea* and *Leucodoniopsis* (both Pleurocarpæ) being new genera. These two papers appeared in *Bull. Soc. Roy. de Bot. de Belg.* 31:—. 1893. In the same journal, 35:—. 1896, the remaining papers of the third fascicle appeared as follows: "Fungi," by Bommer and Rousseau, containing 85 species, 16 of them new; "Filices," by Bommer and Christ, introduced by a general discussion of the pteridophyte flora and containing 251 species, 21 of which are new; "Lycopodiaceæ," by Christ, containing 12 species; "Selaginellaceæ," by Christ, with 16 species; "Begoniaceæ," by C. DeCandolle, with 22 species, 5 of which are new; "Convolvulaceæ," by Hallier, with 23 species; and a second fascicle of "Compositæ," by Klatt, with 105 species, 13 of which are new.—J. M. C.

A TWELFTH *Contribution to the Life Histories of Plants*[12] has been published by Mr. Thomas Meehan. The subjects are sixteen in number, and really represent a fascicle of short papers written long ago. They consist of brief observations which are made the basis of speculative discussions. The subjects are as follows: "Fecundity of *Heliophytum Indicum*," "Origin of the forms of flowers," "Spines in the citrus family," "Flowers and flowering of *Lamium purpureum*," "Cleistogamy in Umbelliferæ," "Rhythmic growth in plants," "Pellucid dots of Hypericum," "Honey glands of flowers," "Varying phyllotaxis in the elm," "Special features in a study of

[11] DURAND, TH. and PITTIER, H.—Primitiæ Floræ Costaricensis. Troisième fascicule. Pp. 297. Bruxelles: Jardin botanique de l'Etat. 1896.

[12] Proc. Philad. Acad. —: 169–203. 1897.

Cornus stolonifera," "Folial origin of cauline structures," "Polarity in the leaves of the compass and other plants," "Hybrids in nature," "Origin and nature of glands in plants," "Nutrition as affecting the forms and their floral organs."—J. M. C.

MR. W. S. BLATCHLEY, state geologist of Indiana, has just published a catalogue of pteridophytes and spermatophytes of Vigo county. This county borders upon the Wabash river, and its flora is one of the most interesting in the state. The full notes of Mr. Blatchley with reference to range and conditions of growth make the catalogue more than a bare list. It is issued as a reprint from the twenty-first annual report of the Department of Geology.—J. M. C.

THE SYNOPSIS of the fleshy fungi and directions for their collection, which Professor L. M. Underwood[13] embodied in the closing dozen pages of the bulletin of the Alabama Experiment Station, recently published on the fungi of that state, have been reprinted and neatly encased in a manilla cover by the Cambridge Botanical Supply Co. The directions for collecting and preserving are clearly and concisely stated in a way to enable one to intelligently avoid the common error of accumulating useless or worse than useless specimens. The genera are provided with keys, some important bibliographical references, and brief notes. The whole forms a valuable aid to collectors of this class of plants.—J. C. A.

IN THESE DAYS, when the science of botany is becoming more and more serious, it is refreshing now and then to catch the flavor of the fields from the standpoint of sentiment rather than of biology. Perhaps it is better to call such a standpoint sentiment suffused with biology. Such a combination is certainly more to be commended than biology suffused with sentiment. No botanist is better able to take the reader afield than Professor W. W. Bailey. His little book "Among Rhode Island wild flowers" has met with a hearty welcome, and now another from his pen extends the view throughout New England.[14]

The months are taken in order, beginning with March, and the prominent plants of the New England flora delightfully described. The style is always sprightly, and the plants mentioned are not so numerous as to degenerate into a catalogue-like monotony.

Special sections are devoted to New England alpines, and plants of the seashore; nor is the winter condition of plants neglected. Aside from the pleasure that such a work brings to the general lover of nature, it will be helpful to teachers who desire help in the nature study.—J. M. C.

[13] UNDERWOOD, L. M.—Suggestions to collectors of fleshy fungi. 8vo. pp. 14. Cambridge: Camb. Bot. Sup. Co., 1897. 25 cents.

[14] W. WHITMAN BAILEY.—New England wild flowers and their seasons. Cloth, 16mo. pp. 150. Providence, R. I.: Preston & Rounds. 1897. 75 cents.

THE PUBLICATION of such papers as the recent "Rearrangement of the North American Hyphomycetes," by Messrs. Pound and Clements, cannot but be a matter of regret to all who hope to see some element of order introduced into the existing chaos which confronts anyone who attempts to concern himself with a systematic study of the fungi. Although the paper is in some respects less open to censure than one of its predecessors (*Botanical Studies*, XXVIII) which was noticed in a former number of the GAZETTE, both represent a type of botanical activity which is to be deplored. For, although the preparation of "Rearrangements" may be a comparatively harmless process so long as it does not, by increasing the existing number of synonyms, serve to increase the difficulties of the subject rearranged through the further complication of a confusion already sufficiently confounded, the right to make such wholesale changes in synonymy as are here proposed can be conceded only to the skilled monographer who shows a knowledge of his subject sufficiently wide and accurate to give weight to his opinions. That these conditions have not been fulfilled in the present instance is indicated by even a cursory examination, the errors of compilation alone, although they are matters of no consequence in themselves, being sufficient to throw doubt on its accuracy in other respects. Taking a few instances at random we find the genus Fusidium credited with about one-quarter of the species "reported" from this country; Cylindrium and Monilia with about one-half, and so on; even the smaller genera being not always correctly represented. It seems incredible that anyone familiar with Corda's figures of Hyphomycetes, or who sees the *Bulletin of the Mycological Society of France*, should retain the genus Synthetospora which already has three synonyms; while discarding entirely as "related to Aspergillus" a genus like Thaxter's Gonatorrhodiella in which the indeterminate basipetal spore formation of the last-mentioned genus is replaced by one that is determinate and acropetal, not to mention other differences. If no place is left among the Hyphomycetes for filing "Aspergillus" forms, whether they be conditions, for instance, of unknown species of "Eurotium" or Cephalotheca, or even of other genera, it is not altogether clear why corresponding places should be maintained for filing other forms, which like those just mentioned are for the most part imperfectly known, while they may contain species connected with more than one genus of "perfect" forms. The rearrangement of species, if anyone may judge from a hasty examination of the lists of new combinations given, seems also based on a none too intimate knowledge of the forms with which such liberties are taken. In a genus like Oospora, which has no characters to speak of, it is a matter of little concern whether we use this name or Alysidium to designate a collection of forms concerning the position and relationships of which we are for the most part ignorant; but in a group like the Helicosporeæ there is no excuse for incorrectly mixing up species unknown to the rearranger; as has for example been done by putting *Helicosporium Curtisii*

or *H. Muelleri* in a genus supposed to be distinguished by hygroscopic spores. The retention without comment of the genus Stigmatella (with Sphaerocreas as a synonym!), and the extraordinary disposition of the genus Illosporium, have also been pointed out by Thaxter in a recent number of the GAZETTE, and serve still further to enforce our contention that work of this kind should be left to the skilled monographer, and can otherwise only serve to complicate difficulties already sufficiently great, when done in connection with a hastily prepared and local "List."—***

NOTES FOR STUDENTS.

MR. M. A. BRANNON has completed his study of the structure and development of *Grinnellia Americana*.[15] The work was done at Wood's Holl, the author occupying the table of the Missouri Botanical Garden. The chief points developed in the study may be summed up as follows: This alga is distinctly an American marine form, flourishing in quiet waters. There are no distinct differences in the vegetative structure of the different fronds, which separate from their holdfasts late in summer, and rising to the surface effect a wide distribution of the fruiting bodies. The cells are nucleated and are connected by protoplasmic pits, except the cells of the procarp, which are connected by open pores. Adult plants are very sensitive to intense light and increase of temperature, but will not grow in shady places. Mutilated plants show great powers of proliferation. The carpospores and tetraspores are very favorable for the study of germination, for while they respond readily to external conditions they are hardy enough to allow a wide range of treatment. The non-motile antherozoids are developed in great numbers by the abstriction of the terminal portion of the apical cells of the antheridia. The cystocarp begins to develop by the modification and apical growth of a joint-thallus-cell. The procarp consists of three cells, and is developed from the supporting thallus-cell in the base of the young cystocarp, and its apical cell becomes the carpogonium. The fertilized contents of the carpogonium are transferred through the open pores connecting the procarpic cells to the supporting thallus-cell, which becomes the central one of the five auxiliary cells. The trichogyne is often branched, and fusion of the antherozoid with it results in great stimulation to the thallus-cell at the base of the procarp, the trichogyne itself being a very evanescent organ. The sporiferous filaments are developed as chains of central cells, from whose branches the carpospores arise acropetally.— J. M. C.

M. PAUL PARMENTIER has published an elaborate paper[16] containing the results of his researches in the anatomy and taxonomy of "Onotheraceæ and

[15] Ann. Bot. 11: 1–28. *Pl. 1–4.* 1897.

[16] Ann. Sci. Nat. Bot. VIII. 3: 65–149. *pl. 1–6.* 1896.

Haloragaceæ." The form of the first family name is accounted for by the claim of the author that "Onothera," not "Œnothera," is the proper form of the generic name. The task set was to discover whether anatomical characters could be of diagnostic use, and if so, to define the families and genera accordingly. We are assured that the researches were "crowned with success." Some of the more interesting conclusions are as follows: the system of crystallization of the calcium oxalate is very constant, and permits the distinct separation of the two families; the structure of the hairs is equal to the crystals in taxonomic value; Ludwigia, possessing the crystals and hairs of both families, is the transition genus (placed by the author in Onotheraceæ as a sub-family); the Haloragaceæ are derived from the Onotheraceæ; Gayophytum and Clarkia are not simply sections of Onothera, and Jussiæa is not a section of Ludwigia; the section Schizocarya of Gaura is worthy of generic rank, and is so placed; anatomical characters serve well to distinguish genera and even specific types of Haloragaceæ, but are not so definite in Onotheraceæ. The author considers further interesting anatomical details for which the paper must be consulted. It will be noted that in the opinion of the author the results do not justify the excessive disintegration of Œnothera to which some of us have been inclined.—J. M. C.

IN A PAPER on teratology[17] M. Casimir De Candolle reaches the following conclusions: If the teratological variations of the floral organs have played a part in evolution, those which have resulted in the present complex forms are today the most rare; and also those monstrosities which are at present the most common indicate, so far as phanerogams are concerned, a tendency to a primitive simplicity of form. Consequently, if the progressive taxonomic monstrosities of the flower were not formerly more frequent and especially more varied than they are at present, they would not have been able to produce, through natural selection alone, that evolution which is thought to have resulted in the complex floral structures of the present day. By progressive variations, M. De Candolle means those which have taken a part in evolutionary progress.—J. M. C.

THE STRUCTURE of the Cyanophyceæ and Bacteria has recently been investigated by Professor Dr. Alfred Fischer.[18] He concludes that in neither of these groups is there a nucleus or any organ resembling a nucleus, but the green rind of the Cyanophyceæ is to be regarded as a genuine chromatophore. It will be remembered that Hegler makes the statement that the so-called "central body" of the Cyanophyceæ is a genuine nucleus which divides by karyokinesis.—C. J. C.

[17] Archives des Sci. Phys. et Nat. IV. 3: [1–12]. 1897.

[18] Untersuchungen über den Bau der Cyanophyceen und Bacterien, *pl. 3*. Gustav Fischer: Jena. *M* 7.

ANOTHER VOLUME of the *Minnesota Botanical Studies* was issued May 31, forming Bulletin no. 9 of the Geological and Natural History Survey of Minnesota. The bulky volume of 341 (703–1043) pages and forty-two plates shows an unusual amount of botanical activity, containing nine papers as follows: Contributions to a knowledge of the lichens of Minnesota, II, by Bruce Fink (pp. 703–725). A rearrangement of the North American Hyphomycetes, by Roscoe Pound and Frederic E. Clements (pp. 726–738). On some mosses at high altitudes, by J. M. Holzinger (pp. 739–742). The forces determining the position of dorsiventral leaves, by R. N. Day (pp. 743–752). On the genus Coscinodon in Minnesota, by J. M. Holzinger (pp. 753–759). Observations on the fern and flowering plants of the Hawaiian Islands, by A. A. Heller (pp. 760–922). The phenomena of symbiosis, by Albert Schneider (pp. 923–948). Observations on the distribution of plants along shore at Lake of the Woods, by Conway MacMillan (pp. 949–1023). The alkaloids of Veratrum, by George R. Frankforter (pp. 1024–1043). The ecological paper by Professor MacMillan is especially noteworthy, since it is the first of its kind published in America. His main results were presented before the Botanical Society of America at its meeting last summer, and were summarized in the GAZETTE of last September. The paper should be a stimulus to many students who ought to turn their attention to this very important field of observation, dealing as it does with the great mass problems of vegetation in relation to environment. It is a kind of work especially adapted to the isolated worker who has no good laboratory and library facilities, and who wishes to do something more than to "collect." Besides, it is the great coming field of botanical activity in America, destined to set aside somewhat the physiological work which has begun to become sterile through its mechanical development in the direction of small and secondary problems.—J. M. C.

MR. C. B. DAVENPORT[19] has been studying the rôle of water in growth. In his paper he first considers the definition of growth in organisms, next analyzes the processes of growth, then shows what an important part water plays in the growth and the significance of this fact for the developmental process in general, and finally discusses the bearing of the new facts upon previously formulated laws of growth. His conclusions are summarized as follows: He recognizes a general parallelism between the developmental processes occurring at the tip of a twig and in the animal embryo. In both there is first a period of rapid cell division with slow growth; next, a grand period in which the general form of the embryo is acquired, the *Anlagen* of the organs are established, and the organism increases rapidly in size by imbibition of water; and, lastly, a period in which histological differentiation is carried on while the absolute growth increments cease to increase. Finally,

[19] Proc. Boston Soc. Nat. Hist. **28**: 73–84. 1897.

the fact that increase in body substance is so largely due to a non-growing substance — water — diminishes the value of the percentage increment curve of growth.—J. M. C.

DR. BRADLEY M. DAVIS[20] has published an interesting account of the vegetation of the hot springs of Yellowstone Park. He finds that many of the peculiar forms of deposit in and about the springs have been determined by the presence of certain algæ. The manner in which these algæ have determined the "columns and moldings" is described in a convincing way. The subject thus opened up is one of great interest, and suggests further research into the conditions of growth in these hot waters. The paper is not a technical presentation of the subject, as the algæ forms concerned have not been sufficiently studied, but it presents the most obvious effects of their presence.—J. M. C.

THE QUESTION of the nomenclature of the North American species of Leucobryum does not seem to be fully settled yet in spite of Mrs. Britton's careful study in the *Bull. Torr. Bot. Club* **19**: 189. 1892. In the *Journal de Botanique* for March 16th, M. Émile Bescherelle discusses the matter and concludes that the following is the correct synonymy:

LEUCOBRYUM MINUS (Dill). Sull.

Bryum albidum et glaucum, fragile, minus Dillen, Spec. Musc. Appendix 546. *pl. 83*. 1741.

Dicranum albidum Bridel, Musc. Recent. 167. 1798.-Spec. Musc. 205. 1806.

Dicranum glaucum var. *albidum* Weber et Mohr, Bot. Tasch. 166. 1807.-Bridel, Bry. Univ. **1**: 409. 1826.

Leucobryum vulgare Hampe var. *minus* C. Müller, Linnæa **18**: 687. 1844.-Synop. Musc. **1**: 75. 1849.

Leucobryum minus Hampe MS. in Sull. Moss. of U. S. 24. 1856.

Leucobryum albidum (Brid). Lindberg, Mossor. Synon. 21. 1863.

Leucobryum minus Hampe *fide* Lindberg in Mossorna uti Dillenii Historia Muscorum 35. 1883.

Leucobryum minus Sullivant in Lesq. et James, Man. Moss. N. Am. 91. 1884.

DISTRIBUTION: Europe: N. America — Ohio (*Sull.* no. 77, 98); Penn. (*Torrey fide* Britton); Central America; Mexico (*Galeotti* no. 6871).

LEUCOBRYUM MINUS (Dill.) Sull. *forma* PUMILA Besch.

Bryum (*Dicranum?*) *minus*, f, *pumilum* Michaux in Herb. Mus. Paris.

Dicranum glaucum: pumilum Michaux, Flora Bor. Am. **2**:— 1803.

Leucobryum vulgare var. *minus* Hampe, Linnæa **13**: 42. 1839 *fide* Mrs. Britton.

Leucobryum sediforme Lesq. et James, Man. Mosses N. Amer. 91. 1884 *fide* Mrs. Britton.

Leucobryum pumilum (Michx.) Britton, Bull. Torr. Bot. Club **19**: 189. 1892.

DISTRIBUTION: N. America — Carolina (*Michaux*); Alleghany mts.

[20] Science **6**: 145–157. 1897.

(*Sullivant* no. 169); Appalachian mts. (*Austin* no. 477 *fide* Mrs. Britton); Florida (*Donnell Smith,* Dec. 1897); Monticello (*Lightpipe*).

LEUCOBRYUM MINUS (Dill). Sull. *forma* INTERMEDIA Besch.

DISTRIBUTION: N. America—Ohio (*Sullivant* nos. 77, 98); S. Carolina (*Ravenel*); Florida (*Durand*).—C. R. B.

PERHAPS THE MOST IMPORTANT recent work in plant geography is that by Johow on Juan Fernandez, undertaken under the auspices of the Chilean government.[21] Juan Fernandez consists of two large islands (Masatierra and Masafuera) and a small rocky island (Santa Clara), several hundred miles west of Chile. The islands are volcanic in origin, dating back no further than the tertiary, and were never connected with the main land. There are steep mountains ascending up to 1800 meters and cut by deep valleys. The author makes an evolutionary analysis of the flora, concluding that the flora has been derived from the mainland, and mostly from Chile. Oceanic and continental islands are contrasted and Juan Fernandez is considered to be an oceanic island, a conclusion in harmony with the absence of land mammals and reptiles. As in most remote islands, there is a small number of species distributed in a relatively large number of genera and orders (143 species of ferns and seed plants in 87 genera and 43 families). The author considers the species, grouping them according to the time of introduction: (*a*) endemic species represent the oldest inhabitants, having diverged most from continental types; 69 endemic species, 12 endemic genera and 1 endemic family are recorded, showing a remarkable degree of endemism, greater than upon any other island group, possibly excepting the Sandwich Islands; (*b*) the autochthones are strikingly similar to Chilean species, 74 species being recorded; their introduction has been brought about by birds, winds and sea currents; (*c*) 71 species were introduced by man unintentionally; (*d*) 24 species have been introduced intentionally and have become naturalized; (*e*) 23 species are strictly culture plants. The plant societies are next discussed as follows, the most important one being (1) the sub-tropical evergreen forest, which extends over half the district. All native trees but one are evergreen, and some introduced trees that are deciduous in their native land have taken on the evergreen habit, *e. g.*, the peach tree. The valley forests are often made up of extensive social growths, while the mountain forests are more mixed. Ferns form an immense part of the vegetation. Many of the plants have large or highly colored flowers, strongly contrasting with the inconspicuous anemophilous flowers of most oceanic islands; the Juan Fernandez species are much more showy than the related Chilean species. Many species are pollinated by humming birds and some by insects. (2) The vegetation of rocky cliffs is

[21] Estudios sobre la flora de las Islas de Juan Fernandez. Obra illustrada con 2 mapas, 8 grabados y 18 láminas—Santiago de Chile, Imprenta Cervantes 1896. 4°. 287 pp. See Eng. Bot. Jahrb. **22**: Heft IV und V, Litteraturbericht, pp. 44–50.

more or less like a steppe, consisting of herbs with scattered shrubs. (3) The strand vegetation is very sparse because of the strong dry winds and scarcity of soil. (4) A very dry stony district characterized by growths of *Avena hirsuta*, (5) Fern steppes. (6) Cultivated areas.

Dusén has written up the results of a Swedish expedition to Terra del Fuego.[22] There are three principal vegetation districts: (1) the northern dry district, largely without forests. There are thickets on small hills near the coast and more or less throughout. There are halophytes on the strand and in saline lagoons, grasses and sedges in the fresh water lagoons. Some portions of the district contain heaths. The woods that occur are almost exclusively of *Fagus antarctica*, with a rather rich herb vegetation, and comparatively few cryptogams. (2) The southern rainy district has extensive forests, the soil being clothed with liverworts, while mosses are comparatively infrequent. Ferns are abundant. Dense thickets occur near the sea. The mountain floras take on something of the aspect of our northern mountain forests, but the coastal flora has a more tropical appearance. (3) The transition district. The introduced plants are successfully combating with the natives. Xerophyte adaptations are seen in the rainy district as well as in the dry area, probably because of the abundance of mists and clouds; the small amount of illumination results in weak assimilation, hence the necessity for protective adaptations. The evergreen habit also facilitates assimilation by extending the period of activity. The crowns of the trees are much spread out hori zontally, thus permitting more assimilation.

Sievers in an article on the physical geography of Venezuela considers some of the more striking plant societies of the country.[23] Twelve plant societies are considered: coastal mangrove swamps, strand vegetation, extensive interior grassy fields or savannas, desert steppes of the Llanos, grassy Morichales, xerophilous thickets with an abundance of cacti, transitional dry woods with an abundance of the Mimoseæ, moister tropical Galerie woods, luxuriant tropical rainy woods, mountain woods with tree ferns, cinchonas and orchids, mountain meadows with an abundance of grasses and perennial herbs, and the Paramos. Vegetation ascends to the snow line because of the moist climate —H. C. C.

ITEMS OF TAXONOMIC INTEREST are as follows: Dr. John K. Small[24] has published an account of the sessile flowered trilliums of the southern states recognizing six species, one of which is described as new, and named for Dr. Underwood. Mr. P. A. Rydberg[25] has begun a description of rarities from Montana, the first three papers containing several new species. Mr. Geo. V.

[22] Botaniska Notiser Hef 6, 1896. See Bot. Cent. Bei. **6**: 519–522.

[23] Petermann's Mittheilungen **42**: 197–201. 1896.

[24] Bull. Torr. Bot. Club **24**: 169–175. 1897.

[25] Op. cit. **24**: 188–192, 243–253, 292–299. 1897.

Nash[26] has described recently several new species of Panicum. Mr. Marshall A. Howe[27] has described a new Californian liverwort, to which he has given the generic name *Gyrothyra*. In its sterile condition it is said to resemble certain forms of Nardia. The type species is dedicated to Dr. Underwood. Dr. John K. Small[28] has published a revision of the species of Tradescantia in the southern states, recognizing eleven species, four of which are proposed as new. Miss Anna Murray Vail[29] has begun a series of papers upon Asclepiadaceæ, in the first number discussing the genus Philibertella, called Philibertia by Dr. Gray. Mr. F. V. Coville,[30] in discussing the name of the camas plant, has given the citations and synonymy of the genus Quamassia, and a synopsis of the species, five of which are recognized. It seems that our eastern *Camassia Fraseri* becomes *Q. esculenta*, while the real camas of the west is *Q. quamash*. Two more new plants from Mount Mazama, Oregon, have been described by Messrs. Coville and Leiberg,[31] being species of Arenaria and Cardamine. Mr. M. L. Fernald[32] has published a second supplement to the Portland catalogue of Maine plants. The recent pages of *Pittonia* which have reached us extend from 159–182. They contain the usual descriptions of new species and discussions of old forms. Chief attention, however, is given to the Compositae, the genus Erigeron being made larger by eight species, the genus Antennaria increased by six species, and the genus Mesadenia of Rafinesque taken up for our species of Cacalia, which genus is thus restricted to African and East Indian forms. Mr. W. N. Suksdorf,[33] in presenting the genus Plectritis and its allies, describes several new species, and proposes the new genus *Aligera*, founded upon *Plectritis macrocera* T. & G. In addition to this species the *Valerianella ciliosa* of Greene is included, and seven new species are described. Mr. J. M. Greenman[34] has prepared a revision of Mexican and Central American species of Houstonia, recognizing twenty-three species, several of which are new. He has also prepared a key to the Mexican species of Liabum. Among the numerous new species from Mexico he has proposed two new genera, *Streptotrachelus* [Apocynaceæ] and *Buceragenia* [Acanthaceæ]. Mr. F. Lamson-Scribner,[35] in his "Studies of American grasses," intends to present certain new and little known species which have been brought to his attention in connection with his preparation

[26] Op. cit. **24**: 192–201. 1897.
[27] Op. cit. **24**: 201–205. 1897.
[28] Op. cit. **24**: 228–236. 1897.
[29] Op. cit. **24**: 305–310. 1897.
[30] Proc. Biol. Soc. Washington **11**: 61–65. 1897.
[31] Op. cit. **11**: 169–171. 1897.
[32] Proc. Portland Soc. Nat. Hist. **2**: 123–137. 1897.
[33] Deutsche bot. Monatsschrift —: 1–4, 143–148. 1897.
[34] Proc. Amer. Acad. **32**: 283–311. 1897.
[35] Bulletin 8, U. S. Depart. Agric. pp. 20. *pl. 8.* 1897.

of the proposed handbook of North American grasses. The present paper includes nine such species. In the same publication Miss E. L. Ogden describes and figures the leaf structure of *Jouvea* and of *Eragrostis obtusiflora*. *Robinsonella* is a new genus of tree mallows described and figured by J. N. Rose and E. G. Baker.[36] In the collections of Messrs. E. W. Nelson and C. G. Pringle and Captain John Donnell-Smith two undescribed species were discovered, which, with an anomalous one described under Sida, are taken to constitute the new generic type. The genus is composed of five species, two of which are Mexican, one Central American, and two South American, but only three species appear in the present paper. The genus is dedicated to Dr. B. L. Robinson, Curator of the Gray Herbarium. Professor Sargent[37] describes and figures *Cladothamnus pyrolæfolius*, a woody ericaceous plant which grows in the upland meadows of Alaska. A second species, long confounded with the Alaskan plant, inhabits Washington and British Columbia, and has been described by Professor Greene as *C. campanulatus*. The folio of *Pittonia* issued July 20[38] completes Part 16. Among descriptions of new species there are "corrections in nomenclature," among which *Atamosco* is is made to replace *Zephyranthes;* and a discussion of certain "ranunculaceous monotypes," *Kumlienia* (*R. hystriculus*), *Arcteranthis* (*R. Cooleyæ*), and *Cyrtorhyncha* (*R. Nuttallii*). A new Antennaria from New England has been described by M. L. Fernald.[39] Dr. Carl Müller has just published[40] descriptions of fifty new species of Jamaican mosses. In a recent number of Engler's *Jahrbücher*[41] the studies of African plants are continued, Schumann completing the Rubiaceæ, proposing four new genera (*Probletostemon, Heinsenia, Paragophyta, Baumannia*); Diels and Engler present the Scrophulariaceæ, the latter proposing four new genera (*Zenkerina, Gerardiina, Thunbergianthus, Strigina*); Pax makes his third contribution to the Euphorbiaceæ; and Hennings presents a second paper on the fungi. In the same journal, of later date,[42] Schumann discusses Phyllocactus and Epiphyllum; Urban presents a fourth fascicle of "Additions to the West Indian flora," which consists of complete lists, with keys to the larger genera, of the great groups Loranthaceæ, and pteridophytes; and Dietel and Niger publish a second contribution upon the Uredineæ of Chili. Hans Hallier[43] has begun a series of notes preparatory to a "monograph of Convolvulaceæ," the first paper being a discussion of nomenclature, and notes on various species.

[36] Garden and Forest **10**: 224–247. 1897.

[37] Garden and Forest **10**: 215 216. 1897.

[38] Pittonia **3**: 183–198 1897.

[39] Garden and Forest **10**: 284. 1897.

[40] Bull. L'Herb. Boiss. **5**: 547–567. 1897.

[41] Bot. Jarbuch. **23**: 449–560. 1897.

[42] Op. cit. **24**: 1–160. 1897.

[43] Bull. L'Herb. Boiss. **5**: 366–387. 1897.

Among them is a section dealing with American forms, two of which are described as new. In the same journal,[44] in connection with studies of lake biology, Chodat publishes much taxonomic material dealing with the algæ of certain French and Swiss lakes, two new genera (*Sphærocystis* and *Stichoglœoa*) being proposed. *Gooringia* is the name of a new genus of Caryophyllaceæ (Alsineæ) from central Tibet, described by F. N. Williams.[45] G. Lindau[46] has published descriptions of new or little known American and Asiatic Acanthaceæ. The American forms are mainly South American, and include six new genera: *Orophochilus* (Peru), *Rhombochlamys* (two species from Columbia), *Psilanthele* (Ecuador), *Megaskepasma* (Venezuela), *Rhacodiscus* (Brazil), *Cylindrosolenium* (Peru). *Tetramerium aureum* Rose is made *Justicia* (*Dianthera*) *aurea* (Rose) Lindau; and *Carlowrightia* (?) *Pringlei* Rob. & Greenm. is said to be *Siphonoglossa Pringlei* (Rob. & Greenm.) Lindau. C. DeCandolle[47] has published an account of the Piperaceæ collected by M. Edouard André in the northern states of South America. *Hicoria pallida* is discussed and figured in *Garden and Forest*.[48]—J. M. C.

[44] Bull. L'Herb. Boiss. 5: 289–314. 1897.
[45] Op. cit. 5: 530–531. 1897.
[46] Op. cit. 5: 643–681. 1897.
[47] Op. cit. 5: 696–711. 1897.
[48] Op. cit. 10: 304–306. 1897.

NEWS.

DR. HERBERT L. JONES has been elected associate professor of botany in Oberlin College.

A BIOGRAPHICAL SKETCH and portait of Baron Ferdinand von Mueller is published in *Jour. Bot.* **35**: 272–278. 1897.

A BIOGRAPHICAL SKETCH and portrait of the late Dr. E. S. Bastin are published in the *Amer. Jour. Pharmacy* **89**: 385–391. 1897.

IT IS ANNOUNCED that Professor Hugo de Vries of Amsterdam has been appointed successor to the late Professor J. Sachs, of Würzburg.

THE OFFICERS of the Botanical Club for the Boston meeting are Conway Macmillan, president; Clare B. Waldron, vice president; and A. B. Seymour, secretary.

PROFESSOR L. H. PAMMEL, of Ames, Iowa, wishes to obtain living and fresh material of mature or nearly mature pods and seeds of the Leguminosæ of Gray's *Manual.*

A BRIEF ACCOUNT of "two southern botanical worthies," Thomas Walter and Dr. Francis Peyre Porcher, is given in a recent issue of *Garden and Forest* (**10**: 301. 1897).

AT THE DETROIT MEETING of the A. A. A. S., Dr. W. G. Farlow was elected vice president of the Botanical Section for the Boston meeting, and Erwin F. Smith, secretary.

MISS ARMA ANNA SMITH, a graduate of Cornell University, receiving the degree of Master of Science in 1896, has been appointed assistant in botany in Mount Holyoke College, Mass.

THE LEAF STRUCTURE of six pieces of Pilocarpus furnishing the commercial jaborandi of the druggist is described and illustrated by Dr. Albert Schneider in the June number of the *Journal of Pharmacology.*

HARVARD UNIVERSITY at the last commencement conferred the honorary degree A. M. upon Mr. Charles E. Faxon, whose work as an acute botanist and an unsurpassed botanical artist well merit this recognition.

PROFESSOR D. T. MACDOUGAL has distributed reprints of his article on "Curvature of roots" (this journal for May) with title page and table of contents added, and with a statement that the paper was presented to the faculty of Purdue University for the degree of Doctor of Philosophy. The doctorate was conferred at the recent commencement in June.

THE NEW OFFICERS of the Botanical Society of America are as follows: N. L. Britton, president; J. C. Arthur, vice president; C. R. Barnes, secretary; Arthur Hollick, treasurer; B. L. Robinson and F. V. Coville, councillors.

THE SAD INTELLIGENCE has just reached us that Dr. J. E. Humphrey died at Port Antonio, Jamaica, August 17, where he was engaged in botanical work with a party of biologists from Johns Hopkins University. No details have been obtained.

AMONG THE AWARDS recently made by the Berlin Academy of Sciences for scientific work, were *M.* 2000 to our associate, Professor Engler, for the publication of monographs on African botany; and *M.* 900 to Dr. G. Lindau for studies in lichens.

DRS. CAMPBELL AND MACDOUGAL were present at the Toronto meeting of the Botanical Society of America, and gave a brief account of their study of Jamaica as a site for a tropical laboratory. The West Indies will be examined further by Drs. Farlow and Coulter during the winter.

PROFESSOR A. S. HITCHCOCK, of the State Agricultural College, Manhattan, Kansas, has published an interesting account of the botanical department of that institution in the *Industrialist*, the college paper. The space given to the work and the apparatus speak of excellent opportunities. The herbarium is said to contain 51,975 specimens, of which 10,000 are fungi.

AMONG THE BOTANISTS who attended the Toronto meeting of the British Association were Bower, Farmer, Green, Marshall Ward, Wager, and Seward from England; Magnus from Germany; Jeffrey and Penhallow from Canada; Arthur, Atkinson, Barnes, Bessey, Britton, Campbell, Coulter, Farlow, Galloway, Greene, MacDougal, Newcombe, and Spalding from the United States.

AT THE DEDICATION of the Hull Biological Laboratories, of the University of Chicago, July 2, a conference was held composed of instructors in botany in universities and secondary schools. The botanical building was occupied by students beginning with the summer quarter, July 1. All of the space designed for courses in morphology has been taken by students, as well as all of the private research rooms.

IT IS ANNOUNCED that the September number of the *American Naturalist* will appear under entirely new management. The magazine has been purchased from the estate of the late Professor Cope by a number of gentlemen, and Dr. Robert P. Bigelow, of the Massachusetts Institute of Technology, has accepted the position of editor-in-chief. There will be also an editorial committee and a board of associate editors, whose names will be announced later.

"THE PHYTOGEOGRAPHY OF NEBRASKA" is the title of a work announced by Dr. Roscoe Pound and Mr. F. E. Clements. The first volume, now in press, will comprise about 350 pages and will be sold for $2.00. "The work deals primarily with phytogeographical problems in Nebraska, but is nevertheless of general interest on account of the treatment of the phytogeographical principles relating to distributional statistics, regional limitation, vegetation forms, habitat groups, plant formations, etc." The publishers are Jacob North & Co., Lincoln, Neb.

THE DIVISION OF BOTANY of the Department of Agriculture has published a bulletin (no. 10) calling attention to three new cruciferous weeds which have been reported from several new localities in the northern United States and Canada during the past four years, in some places having already become aggressive weeds. Although confined as yet to comparatively small areas, and having caused thus far but little damage in this country, the fact that they are spreading in grain fields, meadows, and cultivated lands, and also that they are weeds in the fields of western Europe, are reasons enough for warning the farmers. The plants are *Berteroa incana* (L.) DC., *Conringia orientalis* (L.) Andrz., and *Neslia paniculata* (L.) Desf.

AT THE DETROIT meeting of the Botanical Club, in the absence of the officers, Dr. J. J Davis was elected president, and Albert F. Woods, secretary. Among the subjects presented are the following: Epidemic of *Erysiphe communis* on *Polygonum aviculare;* A phosphorescent mosquito, and Sensitive stamens of *Opuntia fragilis*, by Dr. Charles Bessey; Farmers' institutes, by W. J. Beal; Some interesting oaks, by Professor C. F. Wheeler; Notes on Dicranum, and "Why moss capsules nod," by Dr. R. H. True; A method of preserving the green color of plants, by Mr. A. F. Wood; Winter injury of plum trees in northern Ohio that had been defoliated the previous summer by *Cylindrosporium padi*, by Mr. A. D. Selby; The cultivation of plants on the campus of the University of Michigan, by Professor V. M. Spalding.

A NEW JOURNAL of botany is announced to appear October 1st. The editor is Dr. F. H. Knowlton of the U. S. National Museum, and his associates are Mr. C. L. Pollard, Miss Clara E. Cummings, Mr. Walter Hough, Mrs. N. L. Britton, Miss Josephine E. Tilden, and Mr. A. W. Evans. The magazine will be a 16-page octavo and will occupy an intermediate position between the technical journals and the smaller amateur publications. It will present the facts of plant life in simple, popular language, and aim to interest those who desire acquaintance with plants and their life histories, but who have no inclination for a systematic course of study. The purpose is to be scientific, but not technical. The GAZETTE wishes this new enterprise great success, for it enters upon a large and very useful field. The name is announced as *The Plant World*, an illustrated monthly journal of popular

botany. The subscription price is one dollar, which may be sent to the publishers, Willard N. Clute & Co., Binghamton, N. Y.

THE SMITHSONIAN INSTITUTION has undertaken to bring together all possible material bearing on the medicinal uses of plants in the United States. In November 1896 the Pan-American Medical Congress, meeting in the City of Mexico, took steps to institute a systematic study of the American Medicinal flora. The sub-commission appointed for this purpose in the United States consists of Dr. V. Havard, Mr. F. V. Coville, Dr. C. F. Millspaugh, Dr. Charles Mohr, Dr. W. P. Wilson, and Dr. H. H. Rusby. Dr. Rusby is chairman of the general commission, and Dr. Havard is chairman of the sub-commission for the United States. This sub-commission solicits information concerning the medicinal plants of the United States from anyone in a position to accord it. Detailed instructions as to specimens and notes have been prepared, and all packages and correspondence are to be addressed to the Smithsonian Institution and marked on the outside "Medicinal plants, for the U. S. National Museum." The instructions and the necessary franks will be furnished upon application.

AT THE MEETING of the Academy of Science of St. Louis, May 17, Mr. J. B. S. Norton read a paper upon the effects of the tornado of May 1896, upon trees about St. Louis. It was shown that while ordinary winds have some influence on the form and strength of trees, in strong winds uprooting is caused by wet soil, weak spreading roots, and a large exposed surface. If the roots hold, breaks in trunk or branches may occur depending upon strength of wood, form of tree, mode of branching, and weight and resistance of foliage. It was shown that *Acer dasycarpum* was badly broken on account of its brittle wood and heavy foliage. Trees with spreading tops, like *Ulmus Americana*, were broken and uprooted, though the branches were only bent in the individuals with tougher wood. In general, conical trees like *Ulmus campestris*, *Liquidambar*, most conifers, and the oaks of strong fiber, were little injured. *Taxodium distichum*, from its slender form, strength, and elasticity, was injured least of all. After the tornado, which occurred early in the vegetative period, most of the trees continued growth by producing new foliage shoots. While a few died from inability to secure food, others indicated injury by flowering and fruiting more profusely than usual. Mr. H. von Schrenk also submitted preparations showing the formation of two growth rings in 1896, resulting from the defoliation of the denuded branches.

At the meeting of June 7 Mr. Robert Combs, of Ames, Iowa, presented a paper on a collection of plants made in 1895–6 in the province of Santa Clara, Cuba. The paper contained a full catalogue of the plants, which had been determined at the herbarium of Harvard University. A brief statement was also made concerning the origin of the Cuban flora and its affinities with the Central American flora rather than that of adjacent Florida.

DR. BRADLEY M. DAVIS has sailed for Europe, to be absent for one year.

DR. CHARLES E. BESSEY'S presidential address before the Botanical Society of America will be printed in full in the September number of the BOTANICAL GAZETTE. The subject is "Phylogeny and Taxonomy of the Angiosperms."

MR. WILLIAM WESLEY WOOLEN, a prominent citizen of Indianapolis, and a member of the Indiana Academy of Science, has indicated his intention of presenting to the city a tract of land containing fifty-six acres, to be used as a botanic garden and an ornithological preserve. The tract is very accessible to the city, and is admirably adapted to the purposes indicated. The details of management are now being considered.

THE PRESIDENTIAL ADDRESS of Professor Marshall Ward at the Toronto meeting of the British Association was largely a sketch of the progress of our knowledge of fungi during the Victorian period. The paper brought together in a masterly way the principal advances and defined the present condition of the subject. It will prove an exceedingly valuable reference paper, that might have been enhanced by bibliographical references. The ground traversed was so extensive that the address was fairly encyclopedic.

TWENTY FIVE PAPERS were presented before Section G of the American Association, in addition to the vice presidential address of Professor George F. Atkinson, on "Experimental Morphology." The titles are as follows: *Charles A. Davis*, *Trillium grandiflorum*, its variations normal and teratological; *E. J. Durand*, A discussion of the structural characters of the order Pezizineæ of Schröter; *K. M. Weigand*, The taxonomic value of fruit characters in the genus Galium; *Charles E. Bessey*, Report upon the progress of the botanical survey of Nebraska; *Albert F. Woods*, Bacteriosis of carnations; *Erwin F. Smith*, Wakker's hyacinth Bacterium; *Charles E. Bessey*, Are the trees receding from the Nebraska plains? *C. A. Peters*, Reproductive organs and embryology of Drosera; *J. O. Schlotterbeck*, Development of some seed coats; *J. H. Schuette*, Contributions on wild and cultivated roses of Wisconsin and bordering states; *Fanny E. Langdon*, Development of the pollen of *Asclepias Cornuti*; *Charles E. Bessey*, Some characteristics of the foothill vegetation of western Nebraska; *H. F. Osborn* and *E. B. Poulton*, Organic selection; *James B. Pollock*, Mechanism of root curvature; *Frederick C. Newcombe*, Cellulose ferment; *Rodney H. True* and *C. J. Hunkel*, the toxic action of phenols on plants; *Charles Porter Hart*, Is the characteristic acridity of certain species of the arum family a mechanical or a physiological property or effect? *W. J. Beal*, How plants flee from their enemies; *Alex. P. Anderson*, Stomata on the bud scales of *Abies pectinata*, Comparative anatomy of

the normal and diseased organs of *Abies balsamea* affected with *Æcidium elatinum*, On a new and improved self-registering balance; *Charles O. Townsend*, The correlation of growth under the influence of injurics; *W. W. Rowlee* and *K. M. Weigand*, The botanical collection of the Cornell arctic expedition of 1896; *Erwin F. Smith*, Description of *Bacillus Phaseoli*, n. sp., On the nature of certain pigments produced by fungi and bacteria, with special reference to that produced by *Bacillus solanacearum*.

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VOLUME XXIV NUMBER 3

BOTANICAL GAZETTE

SEPTEMBER 1897

PHYLOGENY AND TAXONOMY OF THE ANGIOSPERMS.[1]

CHARLES E. BESSEY.

It is unnecessary for me to state at the outset what is evident to every botanist, that it is as yet impossible to present a complete phylogeny of the angiosperms. Phytopalæontology is too young a science, and the materials with which it deals are yet far too scanty to have given us direct evidence as to the phylogeny of all families of plants. No one can trace with great certainty from the fossil remains of plants yet discovered the genealogy of any considerable portion of the vegetable kingdom. It will be many a year before the direct evidence we so much desire will leave no considerable gaps to be filled by skillful interpolation. However, after making all due allowance for the imperfection of the record, there are many facts as to past vegetation which are well established. Thus, we know that the earliest plants were simple, homogeneous-celled, aquatic organisms. We know that ferns and gymnosperms preceded angiosperms. We know that the angiosperms which first appeared were of lower types, and that the highest types known today were wanting until very late in geological time.

It is true, moreover, that we are not confined to the direct evidence furnished by the palæontological record. In the individual development of every plant (ontogenesis) there is a

[1] Address of the retiring President of the Botanical Society of America, delivered at Toronto, August 17, 1897.

recapitulation of its ancestral devėlopment (phylogenesis). A critical study of the development of the individual must throw light upon the past history of the species. When we know every step in the formation of each plant we shall be able to trace the phylogeny of every species. Here again we have to face the fact that our knowledge is still quite fragmentary, and that on this account the results are not as definite as we could wish. And yet, when we bring together what we know of the ontogeny of plants here and there in the higher groups, we are able to make out with much certainty not a little as to their phylogeny. To the details regarding these results I shall advert somewhat later.

There is still another line of inquiry open to us, namely, the morphological, in which account is taken of the varying development of homologous tissues, members, and organs. Rightly interpreted, the results of morphological studies are of very high importance in determining genetic relationships. When differences in homologous parts are regarded as but the expression of variation from a common form, they become indices of relationship, and when these indices, obtained from all the tissues, members, and organs of a group of plants, are judiciously considered, they mark out lines of descent with great distinctness.

We have thus open to us three lines of investigation in the study of the phylogeny of plants, namely, (1) the historical, in which the materials are supplied by phytopalæontology, (2) the ontogenetic, in which the development of the individual supplies us with the necessary data, and (3) the morphological, in which the different development of homologous parts is our index of relationship. In this paper I purpose to bring these three lines of investigation to bear upon the problem of the phylogeny of the angiosperms.

GENERAL RESULTS FROM PHYTOPALÆONTOLOGY.

In the Devonian period plants underwent such modifications that we pretty clearly recognize the three types which constitute

the present classes of the pteridophytes,—the ferns, joint-rushes, and lycopods. There appears to be no doubt that heterospory was attained by some of the Devonian pteridophytes. The Lepidodendreæ were quite certainly heterosporous, and possibly the Psilophyteæ should be admitted also. Certain it is that the conifers of this period were heterosporous.

In the Carboniferous and Permian the species and genera of then existing types were multiplied, and the cycads, another heterosporous type, were added. This tendency to heterospory soon resulted in the appearance of plants referred by some authors to the monocotyledons. It is pretty certain at any rate that monocotyledons appeared late in the Palæozoic period or early in the Mesozoic. Of dicotyledons no fossils have been determined with certainty earlier than the Cretaceous, in which period they were evidently quite abundant.

If now we examine with some detail the fossil remains of the angiosperms we find that the earliest recognized were monocotyledons with superior ovaries (Palæospatha, Spirangium, Yuccites, from the Permocarboniferous and the early Mesozoic). Making due allowance for possible errors of determination we find that by the end of the Jurassic period the monocotyledons were probably represented by members of the groups (orders) Apocarpæ, Coronarieæ, Calycinæ, and Glumaceæ. To these we may add, in the Cretaceous, a few representatives of the Epigynæ. In the Tertiary the plants determined are referred to the Apocarpæ, Coronarieæ, Nudifloræ, Calycinæ, Glumaceæ, Hydrales, and Epigynæ. It is interesting to note that the monocotyledonous plants of the Tertiary have been referred mainly to the hypogynous orders, and that none have been identified as representing the Microspermæ. Apparently the evolution of the monocotyledons began with hypogynous species and proceeded toward those in which epigyny is most marked. Orchids are doubtless of very late evolution, so late in fact that none have been preserved as fossils.

The foregoing facts are presented below in tabular form, the per cent. of representation of each group being given for each

period. The data for this table are derived from Schimper,[2] Lesquereux,[3] and Durand.[4]

	Triassic	Jurassic	Cretaceous		Eocene	Miocene	Present
			Lesquereux	Schimper			
Apocarpæ........		30.8	12.5	26.6	29.3	16.1	1.0
Coronarieæ........	100.0	38.4	25.0	6.6	4.3	19.4	14.0
Nudifloræ..........		7.7	12.5	33.3	14.1	7.0	5.5
Calycinæ.		7.7	12.5	26.6	22.8	21.8	6.7
Glumaceæ..........		15.3	12.5	....	25.0	28.3	31.6
Hydrales..........			0.0	0.0	1.1	1.6	.05
Epigynæ..........			25.0	6.6	3.3	5.6	14.0
Microspermæ				0.0	0.0	0.0	25.7

The history of the dicotyledons, as far as yet made out, is relatively simple. In the Cretaceous we find that from 90 to 95 per cent. of the known species may be referred to the two primitive groups (orders) Thalamifloræ and Calycifloræ. Taking Schimper's results, we find that nearly 60 per cent. are referable to the Thalamifloræ, representing nearly equally the groups (sub-orders) Ranales, Caryophyllales, and Malvales. The less important groups, Parietales, Polygalales, Geraniales, and Guttiferales, have not yet appeared; at least no representatives have been certainly recognized.

The Calycifloræ are represented by species of Rosales, Myrtales, Celastrales, Sapindales, and Umbellales. Here the numbers are quite unequal, ranging from about 10 per cent. for Myrtales and Umbellales, to 13 per cent. for Rosales, 26 per cent. for Celastrales, and 40 per cent. for Sapindales. The Heteromeræ and Bicarpellatæ were scarcely represented, Schimper recording but a single species each of Ericales, Ebenales, and Gentianales. If we make use of the data brought together by Lesquereux,[5] we find little change in the general results. There is here a slight preponderance of Calycifloræ

[2] Traité de Palæontologie Végétale. 1869–1874.
[3] The Flora of the Dakota Group. 1891.
[4] Index Generum Phanerogamarum. 1888.
[5] The Flora of the Dakota Group. 1891.

over the Thalamifloræ, 52 per cent. of the former to 48 per cent. of the latter. We note, moreover, that the Ranales include nearly 50 per cent. of the Thalamifloræ, the Caryophyllales 16 per cent., and the Malvales 34 per cent. In the Calycifloræ the Myrtales have but 4 per cent., the Umbellales 12 per cent., the Rosales 24 per cent., and the Celastrales and Sapindales about 30 per cent. each. The Heteromeræ are represented by a few species of Primulales, Ericales, and Ebenales, and there are no Bicarpellatæ whatever. Of the Inferæ there are eight species of Rubiales. It will be instructive to place these results side by side in tabular form.

	Per cent. of species Schimper			Per cent. of species Lesquereux		
CHORIPETALÆ AND APETALÆ	96			92		
Thalamifloræ		60			48	
Ranales			34			50
Parietales			0			0
Polygalales			0			0
Caryophyllales			32			16
Geraniales			0			0
Guttiferales			0			0
Malvales			34			34
Calycifloræ		40			52	
Rosales			13			24
Myrtales			10			4
Passiflorales			0			0
Cactales			0			0
Celastrales			26			30
Sapindales			40			30
Umbellales			10			12
GAMOPETALÆ	4			8		
Heteromeræ		66			72	
Primulales			0			10
Ericales			50			45
Ebenales			50			45
Bicarpellatæ		33			0	
Gentianales			100			0
Inferæ		0			28	
Rubiales			0			100

The significance of these data may be made still more evident by the following diagrams which are drawn to the same proportions (*fig. 1*).

Attention may well be called to the close agreement between the results reached by Schimper and Lesquereux. According to

Schimper, 96 per cent. of the species are apetalous and choripetalous, and but 4 per cent. gamopetalous, while according to Lesquereux 92 per cent. are apetalous and choripetalous, and 8 per cent. gamopetalous. Again, we find that, according to

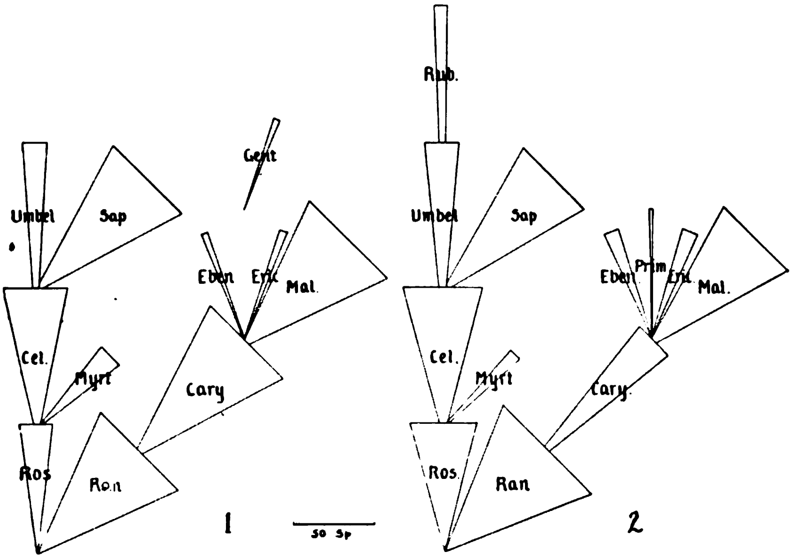

Fig. 1. Diagrammatic comparison of the groups of Cretaceous dicotyledons: 1. according to Schimper; 2. according to Lesquereux. The widths of the triangles indicate relative numbers of species.

Schimper, 80 per cent. of the species have superior ovaries and 20 per cent. inferior ovaries, and these are exactly the proportions in Lesquereux's list. It is worthy of notice, also, that the two lists agree almost exactly in the sub-orders represented, and in the relative number of species in each. Thus in the Thalamifloræ in both lists the Ranales and Malvales are more numerously represented than are the Caryophyllales; in the Calycifloræ, the parallelism is still more marked, the lowest numbers occurring in both lists in Myrtales and Umbellales, intermediate numbers in Rosales, and the highest in Celastrales and Sapindales.

In one particular there is a marked difference between the two lists. Schimper's contains 64 per cent. of apetalous plants, with

but 36 per cent. of those having petals, while Lesquereux's list contains but 42.5 per cent. of apetalous, and 57.5 per cent. of petalous plants. This result is so directly contrary to the commonly accepted notions as to the composition of the dicotyledonous flora of the Cretaceous period that it is worthy of careful consideration. It is possible that this unexpected predominance of the petalous plants is merely the result of the more careful and exhaustive study of the Cretaceous fossils of America, and that when we know more fully the fossil plants of the Cretaceous elsewhere we shall no longer suppose the earlier dicotyledons to have been mainly apetalous. The suggestion is seen to be quite probable when we observe that Lesquereux's earlier report[6] contained 61 per cent. of apetalous to 39 per cent. of petalous plants. Here very certainly the work of twelve or fourteen years upon one formation reversed the numerical proportions between the apetalous and the petalous plants.

In the Eocene period, if we follow Schimper, we find that the families of dicotyledons had risen from twenty-one in the Cretaceous to forty, and that the species were more than three and and one-half times as numerous. The gamopetalous species had risen to 14 per cent., and of the remainder considerably more than one half (57.5 per cent.) were petalous. For the whole of the dicotyledons the per cent. of petal-bearing species had risen to nearly 64. And yet in spite of all this increase we find that the per cent. of species with inferior ovaries remained as in the Cretaceous, or nearly so.

Many families were added in the sub-orders previously represented, and some new sub-orders appeared. Thus in Ranales there were added the Anonaceæ and the Nymphæaceæ. The sub-orders Polygalales and Geraniales appeared, the first represented by the Pittosporaceæ, and the second by the Rutaceæ. To the Malvales were added the Sterculiaceæ and Tiliaceæ; to the Rosales, the three leguminous families (Mimosaceæ, Cæsalpiniaceæ, and Papilionaceæ); to the Celastrales, the Ilicineæ, Celastraceæ, Rhamnaceæ, and Thymelæaceæ; to the Umbellales,

[6] The Cretaceous Flora. U. S. Geol. Survey of the Territories. 1874.

the Cornaceæ; to the Ebenales, the Sapotaceæ, and Styracaceæ; and to the Gentianales, the Oleaceæ, and Apocynaceæ. The suborders Primulales (with Myrsinaceæ 6), Polemoniales (with Convolvulaceæ 2 and Solanaceæ 1), Rubiales (with Caprifoliaceæ 4), and Asterales (with Compositæ 1) complete the list of additions, and give us a hint as to the method of evolution.

Miocene dicotyledons included 66 families, and the species were more than seven times as many as in the Eocene. Here the petalous plants constituted 64 per cent. of the whole, of which nearly 16 per cent. were gamopetalous. The great increase in the number of species was accompanied by a rapid multiplication and modification of previously existing types. Thus we find three more families added to Ranales, three to Caryophyllales, one to Geraniales, three to Malvales, three to Myrtales, one to Sapindales, one to Umbellales, one to Polemoniales, two to Gentianales, and one to Rubiales. The Parietales, Guttiferales, Personales, and Lamiales appear here for the first time. A closer examination of Schimper's list of Miocene plants indicates that in passing from the Eocene to the Miocene, the percentage of species of Ranales was not changed, while that of the Caryophyllales was increased, the Malvales decreased, the Primulales unchanged, the Ericales decreased, the Ebenales slightly increased, the Rosales unchanged, the Myrtales, Celastrales, and Sapindales slightly increased, the Umbellales decreased, the Rubiales and Asterales increased. If we examine the dicotyledonous vegetation of the earth today we may observe that to a limited degree these tendencies to increase or decrease are maintained to the present. This is shown in detail in the following tables (see page 153).

These facts are still more suggestive when presented in diagrammatic form (*fig. 2*, page 154).

After making due allowance for the imperfection of the palæontological record, and our limited knowledge concerning it, it is still safe to say that earlier dicotyledons were of considerably different types from the later, and that from period to period the relative numbers of higher types were increased.

PERCENTAGES OF SPECIES BY SUB-ORDERS.

	Cretaceous		Eocene Schimper	Miocene Schimper	Present Durand
	Lesquereux	Schimper			
Ranales	21.0	18.0	8.0	8.0	3.7
Polygalales	....	....	1.2	0.2	0.9
Caryophyllales	7.0	17.0	3.0	4.0	5.0
Geraniales	....	....	1.2	2.3	5.0
Malvales	16.0	18.0	18.0	9.2	9.8
Rosales	11.6	5.5	11.0	11.0	11.0
Myrtales	1.9	4.4	2.1	2.7	7.5
Celastrales	14.0	11.0	15.1	15.4	5.0
Sapindales	14.7	16.0	22.0	24.5	2.6
Umbellales	6.0	4.4	7.0	2.3	2.3
Primulales	2.2	....	1.8	1.8	1.6
Ericales	2.5	1.1	6.0	3.5	2.1
Ebenales	2.5	1.1	3.0	3.6	1.1
Polemoniales	....	....	0.9	4.3	4.9
Gentianales	....	1.1	0.9	3.5	5.0
Personales	....	....	....	0.4	7.0
Lamiales	....	....	....	0.1	4.5
Rubiales	....	....	1.2	1.5	6.0
Asterales	...	....	0.3	0.9	13.5

PERCENTAGES OF SPECIES BY LARGER GROUPS.

	Cretaceous [7]			Eocene Schimper	Miocene Schimper	Present Durand
	Lesq'x (1)	Lesq'x (2)	Schimper			
Apetalous	61.0	42.5	64.0	36.3	36.0	15.5
Polypetalous	34.0	49.5	32.0	49.6	48.0	36.0
Gamopetalous	5.0	8.0	4.0	14.0	16.0	48.5
Thalamifloræ	54.7	44.0	55.0	30.0	23.5	27.8
Calycifloræ	40.5	48.0	42.0	56.0	58.6	29.5
Heteromeræ	4.7	5.5	2.0	10.7	9.0	4.4
Bicarpellatæ	....	....	1.0	1.8	4.6	19.2
Inferæ	....	2.2	....	1.5	2.5	19.1
Ovary superior	86.8	80.0	80.0	75.4	78.7	65.0
Ovary inferior	13.2	20.0	20.0	24.6	21.3	35.0

[7] For comparison I have given Lesquereux's results in his "Cretaceous Flora" (1), and Flora of the Dakota Group" (2), in addition to Schimper's data. The data for the last column were taken from Durand's "Index Generum Phanerogamarum."

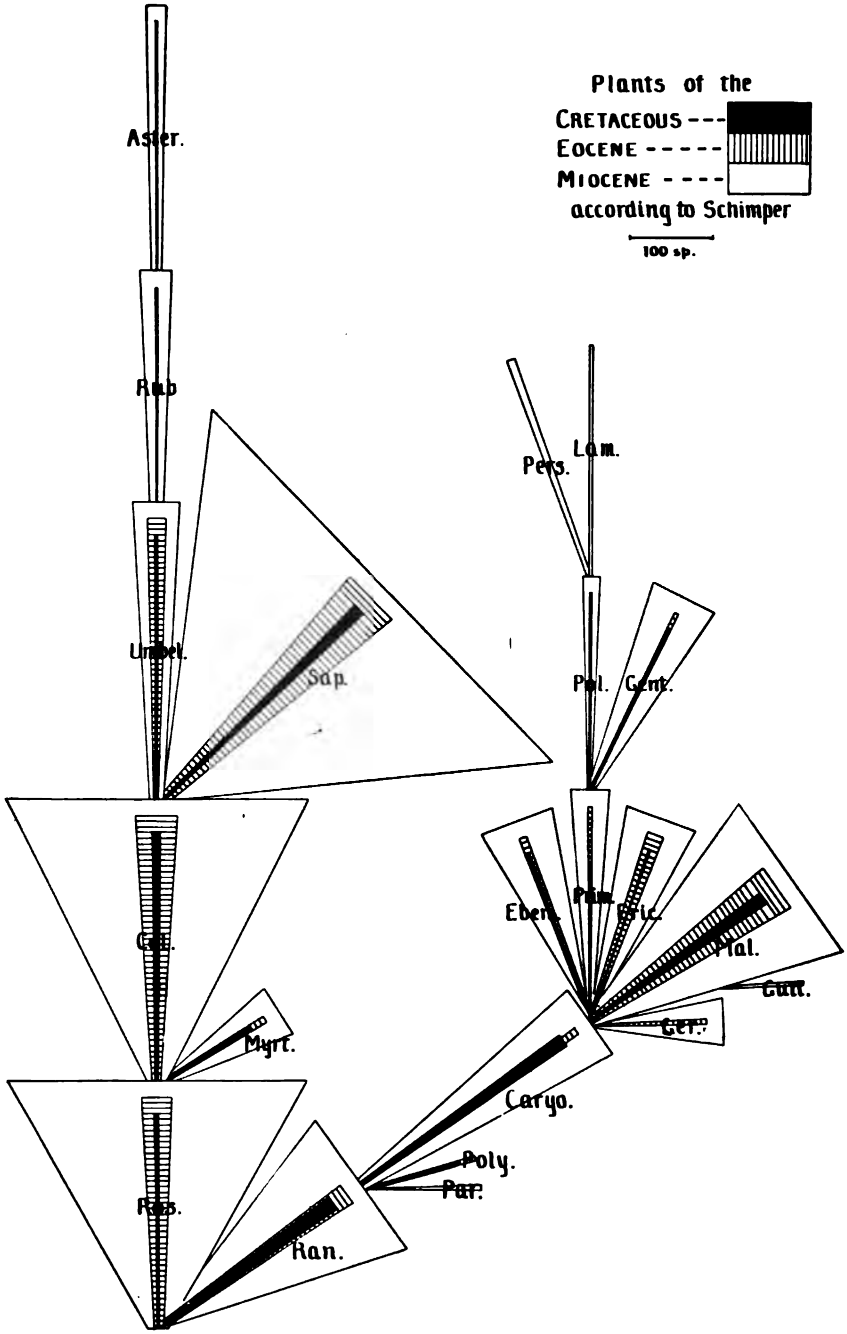

Fig. 2. Diagrammatic comparison of the Cretaceous, Eocene, and Miocene dicotyledonous floras. The widths of the triangles indicate the number of species.

The results of a study of the plants of the Cretaceous, Eocene, Miocene, and the present may be summarized as follows:

1. It is probable that monocotyledons and dicotyledons appeared at about the same time, namely early in the Mesozoic or late in the Palæozoic.

2. The hypogynous monocotyledons appear to have preceded the epigynous monocotyledons, and similarly the petaloideous hypogynous species seem to have somewhat preceded the spadiceous and glumaceous species.

3. Apparently the Thalamifloræ and Calycifloræ are the two earlier types of the dicotyledons.

4. In the Thalamifloræ the three sub-types Ranales, Caryophyllales, and Malvales appear to be earlier than Parietales, Polygalales, Geraniales, and Guttiferales.

5. In the Calycifloræ the Rosales, Celastrales, and Sapindales are the dominant sub-types; here the second and third are greatly reduced in passing to the present, while the first maintains its position with singular persistence.

6. The Myrtales appear to be a growing sub-type, increasing rapidly in passing to the present.

7. The Umbellales, on the other hand, appear to be a waning sub-type.

8. The Heteromeræ have always been of secondary importance.

9. The Bicarpellatæ and Inferæ appear to have developed later than the other types, and to have rapidly increased to the present.

10. In the development of the Bicarpellatæ the Polemoniales and Gentianales preceded the Personales and Lamiales.

11. In the Inferæ the Rubiales led the Asterales.

12. "Polypetaly" appears to have been the common condition in the Cretaceous, Eocene, and Miocene periods.

13. The first modification from polypetaly probably was in the direction of apetaly, a condition reached by many plants in the earlier periods, but by relatively smaller numbers in the present

14. Gamopetaly, from small beginnings, has increased rapidly to the present.

15. Hypogyny has measurably decreased, while epigyny has correspondingly increased.

GENERAL RESULTS FROM EMBRYOLOGY (ONTOGENY.)

After fertilization, the oosphere in all angiosperms divides transversely into two parts, one of which becomes the so-called "suspensor," and the other the embryo proper. The suspensor segment may remain undivided, or it may undergo one or more divisions. The embryo segment at once, or after one or more longitudinal divisions, becomes divided by a transverse wall which separates the foliar (terminal) from the cauline (central) cell or cells. Soon walls form parallel to the surface of the growing embryo, giving rise to a distinct outer layer, the dermatogen, which covers all except the lowermost part of the growing plant. A little later the inner cells of the cauline portion become differentiated into plerome and periblem. Finally, the formation of the root and the root-cap are essentially the same in all angiosperm embryos.

The development of the embryo is so nearly the same in the two sub-classes, that we are compelled to admit their close relationship. The only histological difference which is measurably constant is that the longitudinal division of the embryo takes place before the formation of transverse walls in dicotyledons, and afterwards in the monocotyledons. To this general rule, however, there are numerous exceptions.

If we study the subsequent development of the embryo it is found that the terminal cell, which remains for some time undivided, usually produces a single foliar structure (cotyledon) which is situated terminally upon the caulicle, and that the terminal cell which undergoes early longitudinal division gives rise to two foliar structures (cotyledons). Whether the formation of one or two cotyledons is dependent upon the direction of the separating walls cannot be discussed here. It is at least an interesting coincidence that in the young embryo the undivided

foliar cell gives rise to the single cotyledon, and the divided cell, to the pair of cotyledons.

Thus far in this discussion the embryology of monocotyledons and dicotyledons indicates little more than the close relationship of the two sub-classes. Will it do more? Arc there any indications which may help us to answer the question of the origin of these two groups? Have dicotyledons been derived from monocotyledons, monocotyledons from dicotyledons, or both from some common ancestor? It must be admitted that on theoretical grounds it is no more difficult to pass from two cotyledons to one, than from one to two. Indeed, there have been not a few botanists who have suggested the derivation of the monocotyledons from the dicotyledons. When, however, one compares the two embryos, there is a slight preponderance in favor of the view that the structure is a little higher in dicotyledons than in monocotyledons. The row of undivided cells in the embryo of the monocotyledon after the third or fourth segmentation is certainly a lower structure than the compact mass of cells constituting the "octant-stage" of the dicotyledonous embryo. The cotyledons themselves afford a slight suggestion as to the relationship of the two groups. It is a well established principle in embryology that embryonic stages of higher organisms resemble the adult stages of the organisms which are lower in the same genetic line. Applying this principle to the cotyledons, we observe that while they bear some similarity to the leaves of both monocotyledons and dicotyledons, the similarity is a little more marked in case of the monocotyledons. Compare the mostly sessile, often clasping, usually elongated leaves of monocotyledons with the cotyledons of either class, and contrast these with the mostly petioled, generally not clasping, and usually broad-bladed leaves of the dicotyledons.

But we must not stop with the embryo plant in this comparison. The young plant continues to pass through what are essentially embryonic stages long after it has left the seed, and begun its life as an independent organism. In the ontogeny of

a plant there is no sharp line separating its embryonal from its subsequent life, and in the study of the development of the individual in order to make out the course of development of the species, we must follow its whole life from its beginning to its maturity. The leaves of dicotyledons present an interesting study from this standpoint. It is a well-known fact, as pointed out by Lubbock,[8] that the earlier leaves are generally quite different from the later. In the young plant of the field buttercup of Europe (*Ranunculus arvensis*), for example, the leaves of the first node (cotyledons) are obovate or slightly spatulate; the second leaf, round-cuneate and five-toothed; the third, broadly obovate-cuneate with five large teeth; the fourth, three-parted, the divisions cuneate and three-toothed; the fifth, three-parted, the divisions cuneate, narrower below and four to five-toothed above; the sixth, three-parted, the terminal division irregularly three-lobed, the lateral divisions deeply two-parted, all the subdivisions toothed; the seventh, three-parted, the terminal division again three-parted, the lateral divisions two-parted, all the subdivisions narrow and more or less deeply and narrowly lobed. Here the earlier leaves suggest the mature foliage of *Ranunculus abortivus*, *R. pygmæus*, *R. pedatifidus*, *R. pusillus*, *R. hyperboreus*, and others. It does not require much study to convince one, after an examination of Lubbock's descriptions, that the young plants of different species of Ranunculus are much more alike than are the mature plants. And it is a familiar fact to those who have watched the growth of seedlings of all kinds that in general they resemble one another most when youngest, and that this resemblance becomes less and less as the plants become older. For many seedlings one can do no more when they first appear than to recognize the sub-class to which they belong; a little later the family characteristics may be made out; still later the genus is recognized; while it often happens that we must wait for the flower or even the fruit before we are able to certainly recognize the species. Sow seeds of a buttercup (Ranunculus), a clematis (Clematis), a potentilla (Potentilla),

[8] On seedlings 2, 75, *et seq.* 1892.

a cucumber (Cucumis), a sunflower (Helianthus), a water-plantain (Alisma), an arrow-head (Sagittaria), a lily (Allium), an oat (Avena), and a wheat (Triticum), and when the young plants first appear they will be recognized merely as five dicotyledons and five monocotyledons. But a little later the buttercup, clematis, and potentilla will separate themselves from the cucumber and sunflower, the former resembling one another very much, and having a common buttercup-like look, while the latter resemble one another nearly as much. The families to which the seedlings belong will be indicated next, but it will take longer to separate the potentilla from the buttercup and clematis than the cucumber from the sunflower. The buttercup and clematis will be generically indistinguishable much longer, and had we planted seeds of different species of one of these it would have been still longer before differential characteristics would have appeared. So too with the monocotyledons, the families can be recognized long before the genera, and the genera long before the species.

Now what do these facts indicate? How can we make use of them in our present inquiry? Is it not highly probable that they indicate how and when the differentiation of species from species, of genus from genus, of family from family occurred? If we grow two plants side by side and find them to be indistinguishable until they have formed their fruits, are we not warranted in regarding the relationship a very close one, and may we not safely assume that the separation is a relatively recent accomplishment? There can be no valid objection to the rule that the greater the number of stages of identical development between plants the closer the relationship. This is but another way of expressing the common working rule of botanists that close relationship is shown by the identical structure of many organs. When we know the life history (ontogeny) of a group of plants, and have brought these together so that we shall have well wrought out the comparative ontogeny of all the species, we shall be able to indicate with much exactness their mutual relationship. And when this is done for all of the

groups of angiosperms, their mutual relationship, also, will be indicated.

The most important suggestions as to relationship which have thus far presented themselves in embryology (ontogeny) may be summarized as follows:

1. All angiosperms are essentially alike.

2. The two sub-classes (monocotyledons and dicotyledons) appear to be modifications of a common type which diverged from one another at an early period.

3. There is no indication that either sub-class was derived from the other.

4. There are some structural indications that the monocotyledons must rank lower than the dicotyledons.

5. The vegetative rank of most dicotyledons is so nearly the same as to have left no vestiges on the young plant, which is itself vegetative.

6. The groups into which dicotyledons and monocotyledons are divided are "flower-subdivisions" of a greatly multiplied, rather common vegetative structure; therefore, we may not expect to find upon the embryo or immature plant any vestigial record of their origin.

7. There are some minor structural modifications, as of leaf-shapes, serration, lobing, etc., which appear to have arisen late in the history of the species, and therefore serve as indices of specific and sometimes generic relationship.

GENERAL RESULTS FROM MORPHOLOGY.

Modern morphology concerns itself so largely with the comparative development as well as the comparative anatomy of organs as to make it impossible to draw a sharp line between it and ontogeny. It is by studying the development of organs in the immature plant, from the smallest rudiments to their full growth, that we have been able to make out their homologies. Morphology must include all of embryology and all of ontogeny.

It is needless here to take up in detail the morphology of the cells and tissues of angiosperms. It is enough to remark in

passing that these present similar diversity of form and function in both sub-classes, and that from this fact we may infer the close relationship, if not the common origin of the monocotyledons and dicotyledons.

The tissue systems present no constant differences in the boundary and fundamental systems. Possibly the surface appendages (trichomes) reach a higher development in some dicotyledons than in any monocotyledons. The skeletal system shows some well marked differences. In monocotyledons the fibrovascular bundles are typically separate, while in dicotyledons they are typically united with one another. In the former each bundle is complete in itself, and is often sharply defined by a bounding layer of cells, while in the latter the bundles form parts of an aggregation in which the limits of the individual bundles are often indistinguishable. The shorter life of the bundle in the monocotyledons contrasts sharply with its longer life in most dicotyledons, sometimes reaching hundreds of years, as in the long-lived oaks and chestnuts. And yet these differences, sufficiently constant to characterize the sub-classes, are not invariable. There are skeletal systems in some dicotyledons whose bundles are separate, short lived, and incapable of continued growth, showing again the close relationship of the two sub-classes.

The organs of the plant body present great diversity, and their morphology has long been the subject of much study by many investigators. They may be reduced to the following types: roots, stems, foliage leaves, flower leaves, pollen leaves, ovule leaves.

Roots.—The young roots of monocotyledons are structurally simpler than those of dicotyledons. They rarely increase much in thickness or endure for any great length of time, and are usually unbranched. They contain a single central fibrovascular bundle. The roots of dicotyledons when young contain a single central bundle, but they generally develop several collateral bundles, and are thus able to increase in thickness and to endure for an indefinite time. They are commonly branched again and

again. Here we have as a temporary condition in dicotyledons the structure which is permanent in monocotyledons.

Stems.—The young stems of monocotyledons and dicotyledons differ less than do the old stems of these sub-classes. In young stems of dicotyledons the skeletal system is composed of separate fibrovascular bundles which traverse the parenchymatous ground tissue, and at this stage the hypodermal tissues are not unlike, either in composition or arrangement. In herbaceous stems this similarity is maintained much longer than in woody stems, where the dissimilarity eventually becomes extreme. The important difference between these two types of stems is that the skeletal tissues combine to form a single solid column in the dicotyledons, while they do not in the monocotyledons. Now when to this we add the fact that the bundles of dicotyledons have fused in such a manner that their continued growth adds to the mass of the skeletal column, thus giving to the stem the possibility of indefinite increase in mass, we have again an indication of the higher rank of this sub-class.

In regard to external morphology it may be remarked that in monocotyledons there are two well defined modifications of the normal type of vegetative stem, as seen in lilies, naiads, orchids, etc. One extreme of this modification occurs in the grasses and sedges in which the internodes are greatly elongated, and the other in palms and screw-pines, in which the internodes are usually so short as to be scarcely recognizable. The suggestion which these stem modifications offer as to the relationship of grasses and sedges on the one hand, and palms and screw-pines on the other, to the lilies is obvious.

Leaves.—In general structure the leaves of angiosperms are essentially alike. The significant differences may be enumerated as follows:

1. The leaves of monocotyledons are usually entire, elongated, parallel-veined blades, placed alternately or scattered upon the stem, to which they are attached directly (in sessile leaves) or indirectly (in petioled leaves) by a commonly broad base which is rarely supplied with stipules.

2. The leaves of dicotyledons are entire or more commonly dentate or lobed, usually broad, netted-veined blades, opposite, alternate, or scattered upon the stem, to which they are usually attached indirectly (petiolate) by a narrow base (rarely by a broad base), which is commonly supplied with stipules.

These structural differences are mainly due to differences in development. The parallelism of venation and the general absence of lobing in the leaves of monocotyledons result from the localization of growth at the base of the blade or in definite bands on each side of its axis, and commonly the netted venation in the leaves of dicotyledons results from the longer continued and more or less irregular growth of all parts of the blade; and it is to this irregularity of growth, also (especially in the peripheral portions), that the serrations, dentations, lobings, etc., are due. The development of a petiole is correlated with the assimilatory function of the leaf, and in both sub-classes is less or more, according to the degree of its illumination. The broad basal attachment in monocotyledons may depend upon the looser disposition of the fibrovascular bundles in the stems, or possibly it may indicate that leaf and stem are not yet as fully differentiated as they are in dicotyledons, a view which receives some confirmatory suggestion from the presence of an articulation at the base of the leaf in most dicotyledons, while it is absent from most monocotyledons. The significance of the stipules is not so obvious; probably their more frequent occurrence in dicotyledons is correlated with the more common development of the petiole in this sub-class.

The particular morphology of leaves is commonly indicative of relationship between species and genera, and now and then it has a broader significance. In the monocotyledons the common type of leaf is particularly modified in the sedges and grasses, this modified type being maintained with great constancy throughout the two great families. Among dicotyledons the greatly branched ("compound") leaves of mimosas (Mimosaceæ), brasilettos (Cæsalpiniaceæ), sumachs (Anacardiaceæ), walnuts (Juglandaceæ), and umbellifers (Umbelliferæ) are characteristic

of the families, and so too are the opposite leaves of the verbenas (Verbenaceæ), mints (Labiatæ), honeysuckles (Caprifoliaceæ), and madderworts (Rubiaceæ).

Flower leaves.—The reproductive strobilus of angiosperms consists of a stem upon which are developed spore-bearing and sterile leaves. Whether the sterile leaves were originally derived from the spore-bearing ones by a process of sterilization, as suggested by Bower,[9] need not be discussed here, since such sterilization, if it ever occurred, must have taken place long before the ancestors of the angiosperms crossed the line which separates the Pteridophyta from the Spermatophyta. We have here to deal with the reproductive strobilus in the form of the flower, in which the sterile leaves are well set off from those which bear spores.

In the simpler cases the sterile leaves (perianth) are separate from one another, and this doubtless represents their primitive structure. In other cases the flower leaves have fused more or less in their growth, this doubtless being a structure derived from the simple primitive condition referred to above. In many flowers the perianth leaves show no differentiation from one another, while in others they are very unlike. In this matter it is reasonable to suppose that the primitive flower leaves were at least approximately alike in form and dimensions, and that unlikeness in these particulars arose as a modification of the primitive structure. Again we find that in many flowers the sterile leaves are in no way connected with the spore-bearing leaves, the former being attached at a distinctly lower level upon the stem. In other cases, however, there is more or less union between the sterile and spore-bearing leaves, in extreme cases amounting to complete fusion. Here again it is not hard to recognize in united and fused leaves a structure derived from the more primitive free leaves. This union of parts may receive the general designation of *symphysis*.[10]

Some flowers have a scanty perianth (apetalous) and others,

[9] A theory of the strobilus in archegoniate plants. Ann. Bot. **8**: 343. 1894.

[10] Greek σύμφυσις, a growing together, natural joining.

again, none at all (naked). Since these often occur on plants which are clearly related to those bearing a fully developed perianth, we are led to the conclusion that apetalous and naked flowers are modifications of the common flower structure. Thus, there can be no question as to the relationship of Clematis, Anemone, Thalictrum, Caltha, Hydrastis, etc., to Ranunculus, Myosurus, Coptis, Delphinium, and other genera of Ranunculaceæ. So, too, who questions the relationship of our apetalous maples (*Acer saccharinum* L. and *A. negundo* L.) to the remaining species of the genus, or of our ashes (Fraxinus sp.) to the old world petalous species? In these and many other cases we see clearly that the apetalous condition of the flower is one derived from the normal structure in which the complete perianth is present. There are, however, many apetalous dicotyledons whose relationship botanists have not been able to agree upon. Thus Bentham and Hooker in their *Genera Plantarum* enumerate thirty-six families, including 849 genera, and 12,100 species, in the artificial group Monochlamydeæ, which they separate from their Polypetalæ solely by the simple (or absent) perianth; Engler and Prantl in their *Pflanzenfamilien* bring together into a heterogeneous group twenty-four families of mostly apetalous plants, including nearly 6000 species. All of these, excepting the Olaceæ, are included in Bentham and Hooker's Monochlamydeæ, so that we have in Engler and Prantl's arrangement a reduction of Monochlamydeæ amounting to fully one-half. This has been accomplished by a distribution of apetalous plants among those whose flower structure differs only in regard to the perianth. That this reduction could have been carried further without doing violence to our knowledge of relationship will be admitted by most systematic botanists. Thus we may readily remove the Olacaceæ, which have a perianth consisting of calyx and corolla, and with them may go the sandalworts (Santalaceæ), proteads (Proteaceæ), loranths (Loranthaceæ), and perhaps the balanophorads (Balanophoraceæ), all of which are more or less clearly related to the typical Celastrales. So too the willows and poplars (Salicaceæ) differ from the tamarisks (Tamaricaceæ) only

in the absence of a perianth, the "gynæcium, placentation, ovules, fruit and seeds agreeing completely," as pointed out by Niedenzu[11] in his discussion of the relationship of Tamaricaceæ.

If we were to suggest a natural classification of the dicotyledons based upon the morphology of the sterile flower leaves alone, we should group together first those plants with all their flower leaves free from one another; this would constitute our primitive group. In another place we should bring together all those in which the sterile and spore-bearing flower leaves have undergone the greatest fusion; this would constitute our highest group. Between these we should have to arrange the intermediate conditions. Then remembering that the perianth readily becomes much reduced we should have to give such place and position to each apetalous plant as its structure otherwise demanded.

Pollen leaves (microsporophylls, stamens).—The normal position of these is between the sterile and the ovule leaves. In many cases they are quite separate from one another and from the other leaves of the flower, but in many other cases they are united to one another, or to the leaves below or above.

Numerically the pollen leaves show great diversity. This is correlated with the greater or less amount of pollen required to insure the production of seeds in the different species. In general, no organs of the flower exhibit so little constancy in structure, dimensions, number, or position as the pollen leaves, and yet within narrow limits these inconstant organs often present a surprising conformity to a single type. They serve well, therefore, to define the smaller groups, but have little value as indicating broader relationships.

Ovule leaves (macrosporophylls, carpels).—These occupy the highest portion of the strobilus, and are normally separate organs, unconnected with one another or with other organs. In buttercups (Ranunculaceæ), potentillas (Rosaceæ), and water-plantains (Alismaceæ) the carpels are many and separate, while in pinks (Caryophyllaceæ), saxifrages (Saxifragaceæ), and lilies (Liliaceæ) they are more or less united with one another, thus

[11] ENGLER and PRANTL. Die Natürlichen Pflanzenfamilien 3^6: 291.

forming a single syncarpium, the so-called "compound pistil" of descriptive botany. Many syncarpia still preserve some of their parts free from one another; thus in the saxifrages, most pinks, and some lilies, the carpels are united for only a part of their length, the terminal portions (styles) being free, while in myrtles (Myrtaceæ), primroses (Primulaceæ), and spiderworts (Commelinaceæ) they are fully united from end to end. All apocarpia are free from the other organs of the flower, and this is the case with many syncarpia. There are, however, many syncarpia to which some or all of the other leaves of the reproductive strobilus have become more or less completely attached. In the so-called epigynous flowers, as the irids and orchids among the monocotyledons, and the myrtles, cactuses, umbelworts, and all of the Inferæ of the dicotyledons, there has been such a fusion of the originally separate parts of the strobilus as to result in a single compact structure in which in extreme cases only the distal portions of the original leaves are distinguishable.

The primitive syncarpia of the monocotyledons appear to have contained three carpels, as in lilies, and those in dicotyledons five or more, as in pinks and mallows. In the fusion of the parts of the strobilus some of these are usually suppressed. As a result we find that in case of the greatest fusion the syncarpium contains fewer than the normal number of carpels, as for example, in the Asterales of the dicotyledons, where there are but two carpels remaining, and these so reduced as to function as but one. The genetic line which includes pinks (Caryophyllales), primroses (Primulales), phloxes (Polemoniales), figworts (Personales), and mints (Lamiales) illustrates this tendency to a reduction in the number of parts with increased fusion of the strobilar leaves. The same law is illustrated in the genetic line which includes the lilies (Coronarieæ), pipeworts (Eriocaulaceæ), sedges (Cyperaceæ), the lower grasses (Bambuseæ), and higher grasses (Agrostideæ and Paniceæ); or possibly still better in the line from lilies to amaryllids (Amaryllidaceæ), irises (Iridaceæ), burmannias (Burmanniaceæ), and orchids (Orchidaceæ).

It will be seen from the foregoing discussion of the reproductive strobilus that there are two principal modifications to which it is subject, namely (*a*) *symphysis*, that is, a fusion of parts, and (*b*) *aphanisis*,[12] a suppression of parts. These may separately or jointly affect some or all parts of the strobilus, resulting in the multitude of forms which it assumes. Aphanisis alone results in apetaly and diclinism; symphysis alone, in such a type as we find in myrtles and cactuses.

We may summarize the results from a morphological study of plants as follows:

1. The identity of the cells and tissues of the two sub-classes of angiosperms indicates their close relationship.

2. The fibrovascular tissue-system of the dicotyledons indicates that this sub-class is higher than the monocotyledons.

3. The roots of dicotyledons indicate that this sub-class is higher than monocotyledons, and suggest the possibility of the origin of the former from the latter.

4. The structure of the dicotyledonous stem indicates the higher rank of this sub-class.

5. Among monocotyledons the external morphology of the stem indicates the derivation from lily-like plants of the palms and screwpines by an excessive shortening of internodes, and of sedges and grasses by a corresponding elongation.

6. The general morphology of the leaves of monocotyledons and dicotyledons, as has already been indicated many times, emphasizes the close relationship of the two sub-classes, and repeats the suggestion that the former include plants which must take rank below the dicotyledons.

7. The particular morphology of leaves commonly indicates specific or generic relationship, but now and then they possess a sufficient constancy to serve as indices of family relationship.

8. There are two principal modifications of the flower strobilus—namely, symphysis and aphanisis—which separately or jointly affect some or all of its parts.

[12] Greek ἀφάνισις, a getting rid of, a vanishing, a disappearance.

9. The perianth of separate leaves becomes modified by their fusion with one another and with other strobilar leaves (symphysis). The reduction (aphanisis) of the perianth is a modification of much less morphological significance, and is rarely, if ever, indicative of broad relationships.

10. The pollen leaves show constancy in structure, dimensions, number, and position only within narrow limits, and therefore serve to define the smaller groups (families and tribes), but have little value as indices of broad relationships.

11. In the symphysis of the primitive apocarpous flower strobilus the carpels first unite into a syncarpium, and with this process of fusion there is generally a progressive reduction (aphanisis) in the number of constituent carpels.

12. The extreme modification of the flower strobilus results in the fusion of all the constituent parts (symphysis) and their reduction in number (aphanisis).

From all the foregoing we may pretty safely proceed to construct the hypothetical phylogeny of the angiosperms, to serve as the basis of their taxonomy. And let it be fully understood that this is not presented as final, or as entirely satisfactory; it is merely a working hypothesis, which claims no other merit than that of an attempt at conformity to the suggestions sometimes faint, sometimes doubtful, from palæontology, from embryology (ontogeny), and from morphology. That some of these suggestions have been misinterpreted, or that others have been overlooked, is altogether likely; but in this I must beg the indulgence of systematists, who may well realize the difficulties surrounding the problem here undertaken.

HYPOTHETICAL PHYLOGENY OF ANGIOSPERMS.

The angiospermous phylum parted very early into two subclasses, the monocotyledons and dicotyledons. This separation took place while the flower strobilus was still apocarpous, and before any of the strobilar leaves had undergone much, if any, modification. At this stage the vegetative characters of the

sporophyte were so well established that no profound modifications have been undergone since.

The modifications which gave us the main lines of monocotyledons were first the fusion of the carpels with one another and the production of a syncarpium, and second the progressive fusion of the syncarpium with the other strobilar leaves. These resulted in the phylum which begins with Apocarpæ and passes to Coronarieæ, Epigynæ, and Microspermæ. In some Apocarpæ and many plants of the type of the Coronarieæ the perianth has been more or less reduced (by aphanisis), in some cases amounting to complete suppression, as in palms (Calycinæ), aroids (Nudifloræ), and sedges and grasses (Glumaceæ).

The primitive dicotyledons were apocarpous plants which soon developed along two diverging lines, characterized in the one case by the tendency of the leaves of the strobilus to fuse with each other in a transverse direction (transverse symphysis), while in the other the tendency was to a fusion of the leaves in two directions (transverse and longitudinal symphysis). The phylum resulting from the predominance of transverse symphysis began with the apocarpous Ranales, soon developing into the syncarpous Caryophyllales and Malvales. The type of the Caryophyllales became slightly modified in the Primulales by the transverse symphysis of the inner perianth whorl resulting in gamopetaly. In the Polemoniales the type of the Primulales began to undergo modification by aphanisis, resulting in a reduction of the microsporophylls to five, and the carpels in the syncarpium to two or three. Increasing aphanisis produced the Personales and Lamiales with their four or two microsporophylls and irregular perianth, and in the latter group with each carpel restricted to the production of but one or two macrosporangia.

The phylum in which both transverse and longitudinal fusion are well marked proceeds from the apocarpous roseworts (Rosaceæ) to the syncarpous saxifrages (Saxifragaceæ) of the Rosales, to the Celastrales, in which epigyny is sometimes attained, thence to the Umbellales, where epigyny is constant, and to the Rubiales, in which gamopetaly has become a fixed

character, culminating in the group of the Asterales with its greatly reduced bicarpellary syncarpium.

Early predominance of aphanisis in the ranal phylum soon gave rise to the apetalous laurels (Lauraceæ) and nutmegs (Myristicaceæ) from the buttercup type. A somewhat later appearance of aphanisis gave rise to the willows (Salicaceæ), amaranths (Amaranthaceæ), and buckwheats (Polygonaceæ) from the pink type; and the spurgeworts (Euphorbiaceæ) and nettle-worts (Urticaceæ) from them allow type. Similarly, early predominance of aphanisis in the rosal phylum gave rise to the apetalous plane-trees (Platanaceæ) from the rosewort type; while its later appearance gave rise to the proteads (Proteaceæ), daphnads (Thymelæaceæ), oleasters (Elæagnaceæ), sandalworts (Santalaceæ), and loranths (Loranthaceæ) from the holly type; and the walnuts (Juglandaceæ), oaks (Fagaceæ), and gale-worts (Myricaceæ) from the horse-chestnut type (Sapindales).

Early predominance of symphysis gave rise to the peculiar group of the myrtles (Myrtales) from the rosewort type, in which by later aphanisis, hippurids (Halorageæ), birthworts (Aristolochiaceæ), vine rapes (Cytinaceæ) were produced. The Parietales and Polygalales arc later developments more or less parallel to the Caryophyllales; while the Geraniales and Guttiferales stand in a similar relation to the Malvales.

THE TAXONOMY OF ANGIOSPERMS.

It should not be necessary to urge at this time the desirability of a conformity between phylogeny and taxonomy, and yet it may be well to call to mind the words of Dr. Gray:

We have supposed, and Naegeli takes a similar view, that each plant has an internal tendency or predisposition to vary in some directions rather than others; from which, under natural selection, the actual differentiations and adaptations have proceeded. Under this assumption, and taken as a working hypothesis, the doctrine of the derivation of species serves well for the coordination of all the facts in botany, and affords a probable and reasonable answer to a long series of questions which without it are totally unanswerable. It is supported by vegetable palæontology, which assures us that the plants of the later geological periods are the ancestors of the actual flora

of the world. In accordance with it we may explain in a good degree the present distribution of species and other groups over the world. It rationally connects the order of the appearance of vegetable types in time with the grades of differentiation and complexity, both proceeding from the simpler, or lower and more general, to the higher and more differentiated or special; it explains by inheritance the existence of functionless parts; throws light upon the anomalies of parasitic plants in their various gradations, upon the assumption of the most various functions by morphologically identical organs, and indeed illuminates the whole field of morphology with which this volume has been occupied. It follows that species are not "simple curiosities of nature," to be catalogued and described merely, but that they have a history, the records of which are impressed upon their structure as well as traceable in their geographical and palæontological distribution.[13]

In an adjoining paragraph he tersely sums up the matter in this aphorism:

Affinity under this view is consanguinity, and classification, so far as it is natural, expresses real relationship.

We are warranted in strenuously urging a conformity of taxonomy with phylogeny, and while we must be cautious not to propose a new arrangement for every phylogenetic vagary which may arise, we must be equally careful not to allow our natural inertia, or the conveniences of the art of botany, to retard any change demanded by science.

Four years ago I discussed[14] the insufficiency of the Candollean system, and a year ago that of the system of Engler and Prantl[15] as expressions of genetic relationship. Further study of the problem and of these systems has deepened my conviction that while each is doubtless the best formula of the results of its period, neither one is today an adequate expression of our knowledge of the structure and relationship of the angiosperms. We are not to imagine, however, that the work of the past is to be thrown aside as worthless, and that the system based upon phylogeny will have nothing in common with the older systems. On the contrary, when examined critically,

[13] Structural Botany 330.

[14] Evolution and classification. Proc. A. A. A. S. **42**: 237.

[15] The point of divergence of monocotyledons and dicotyledons. BOT. GAZ. **22**: 229.

the system which seems to us to be more nearly in accord with our knowledge of phylogeny does not differ as much from the two older systems as they differ from one another. It is only when we make a superficial comparison of the Candollean system (as wrought out by Bentham and Hooker) and Eichler's system (as modified by Engler and Prantl) that they seemed to be radically or even greatly different. Engler and Prantl have reduced by one-half that troublesome mass of poorly understood plants, the Apetalæ; then beginning with the Ranales and Parietales a similar sequence of choripetalous groups is taken up in each, this becoming identical near its central course, and towards its culmination in the Umbellales. The only difference in the treatment of the Gamopetalæ is that in order to emphasize relationship with the Umbellales the Inferæ are placed first in Bentham and Hooker's system, while in the system of Engler and Prantl they are placed last, the emphasis here being given to their rank as the highest of dicotyledons.

Bringing together the results of the studies of these masters as shown in their systems, and still better in their discussions of relationship under each family, and using our hypothetical phylogeny as a general guide, we find it possible to make such modifications of the two systems as will give us an arrangement which fairly agrees with the present state of our knowledge.

The angiosperms are separable into two diverging subclasses, the monocotyledons (Monocotyledoneæ) and the dicotyledons (Dicotyledoneæ), the first ranking structurally lower than the second. The monocotyledons are well divided by Bentham and Hooker into seven series, and these we may accept unchanged, with the single exception that the waterworts (Hydrocharitaceæ) should probably be removed from the Microspermæ to constitute an additional coordinate group. These eight groups, which appear to be deserving of no more than ordinal rank, should then be rearranged so as to have the following sequence, namely: Apocarpæ, Coronarieæ, Nudifloræ, Calycinæ, Glumaceæ, Hydrales, Epigynæ, Microspermæ. Here it must be understood that the Nudifloræ, Calycinæ, and Glu-

maceæ are separate orders radiating from the present order Coronarieæ, and that the Hydrales constitute a diverging order from the base of the Epigynæ. The distribution (but not necessarily the exact sequence) of families among the orders may be indicated as follows:

ORDER APOCARPÆ.

Families: Alismaceæ, Triurideæ, Naiadaceæ.

ORDER CORONARIEÆ.

Families: Stemonaceæ, Liliaceæ, Pontederiaceæ, Philydraceæ, Xyridaceæ, Mayaceæ, Commelinaceæ, Rapateaceæ.

ORDER NUDIFLORÆ.

Families: Pandanaceæ, Cyclanthaceæ, Typhaceæ, Aroideæ, Lemnaceæ.

ORDER CALYCINÆ.

Families: Flagellariaceæ, Juncaceæ, Palmaceæ.

ORDER GLUMACEÆ.

Families: Eriocaulaceæ, Centrolepidiaceæ, Restiaceæ, Cyperaceæ, Gramineæ.

ORDER HYDRALES.

Family: Hydrocharitaceæ.

ORDER EPIGYNÆ.

Families: Dioscoreaceæ, Taccaceæ, Amaryllidaceæ, Iridaceæ, Hæmodoraceæ, Bromeliaceæ, Scitamineæ.

ORDER MICROSPERMÆ.

Families: Burmanniaceæ, Orchidaceæ.

The choripetalous and gamopetalous dicotyledons are divided by Bentham and Hooker into six "series," one of which, the Disciforæ, should be broken up and its families distributed elsewhere. The remaining "series," which appear to have the rank of orders, form two somewhat diverging genetic lines or phyla, each beginning with apocarpous, hypogynous, choripetalous plants, and both attaining syncarpy and gamopetaly, one remaining hypogynous, the other becoming epigynous. An attempt has been made to distribute all the apetalous plants, these having been assigned places in the lower two orders.

Since gamopetaly has evidently been attained at more than one point, it is no longer desirable to retain the Gamopetalæ as a distinct group. It must constantly be borne in mind that these orders and their sub-orders, as well as the families, are diversely related to one another, sometimes serially, but more commonly divergently, as the twigs of a tree are related, now by direct extension, and then by lateral branching (see *fig. 3*).

It still remains to work out the particular relationship of the families to one another in the orders of monocotyledons and the sub-orders of dicotyledons, in accordance with the general principles here laid down. This the present writer hopes to complete within the next year or two, having already accomplished somewhat in this direction. This will prepare the way for a natural arrangement of the genera in the families, a task which may well claim many years for its completion.

The distribution (but not necessarily the exact sequence) of the families among the orders may be indicated as follows:[16]

ORDER THALAMIFLORÆ.

Sub-order Ranales.

Families: Ranunculaceæ, Dilleniaceæ, Calycanthaceæ, Magnoliaceæ Anonaceæ, Myristicaceæ, Monimiaceæ, Chloranthaceæ, Menispermaceæ, Benberidaceæ, Lauraceæ, Nymphæaceæ.

Sub-order Parietales.

Families: Sarraceniaceæ, Papaveraceæ, Cruciferæ, Capparidaceæ, Resedaceæ, Cistaceæ, Violaceæ, Canellaceæ, Bixaceæ, Samydaceæ, Lacistemaceæ, Nepenthaceæ.

Sub-order Polygalales.

Families: Pittosporaceæ, Tremandraceæ, Polygalaceæ, Vochysiaceæ.

Sub-order Caryophyllales.

Families: Caryophyllaceæ, > Frankeniaceæ, Tamaricaceæ, Salicaceæ; > Portulacaceæ, Ficoideæ; > Phytolaccaceæ; > Nyctaginaceæ; > Illecebraceæ, Amaranthaceæ, Chenopodiaceæ, Polygonaceæ; > Batideæ (?).

[16] In some sub-orders which have been more exhaustively studied a rearrangement of the families has been made and genetic lines indicated by the sign > which may be read "from whence came," each line being derived from the family first named in the sub-order.

Sub-order Geraniales.

Families: Linaceæ, Humiriaceæ, Malpighiaceæ, Zygophyllaceæ, Geraniaceæ, Rutaceæ, Simarubaceæ, Ochnaceæ, Burseraceæ, Meliaceæ, Dichapetalaceæ.

Sub-order Guttiferales.

Families: Elatinaceæ, Hypericaceæ, Guttiferæ, Theaceæ, Dipterocarpaceæ, Chlænaceæ.

Sub-order Malvales.

Families: Tiliaceæ, >Sterculiaceæ, Malvaceæ; >Urticaceæ, Leitneriaceæ; >Euphorbiaceæ, Balanopseæ, Empetraceæ; > Ceratophyllaceæ, Podostemaceæ; > Piperaceæ.

ORDER HETEROMERÆ.

Sub-order Primulales.

Families: Primulaceæ, > Plumbaginaceæ; > Myrsinaceæ; > Plantaginaceæ.

Sub-order Ericales.

Families: Ericaceæ, > Vacciniaceæ; > Epacridaceæ, Diapensiaceæ; > Clethraceæ, Pirolaceæ, Lennoaceæ.

Sub-order Ebenales.

Families: Sapotaceæ, Ebenaceæ, Symplocaceæ, Styracaceæ.

ORDER BICARPELLATÆ.

Sub-order Polemoniales.

Families: Polemoniaceæ, >Convolvulaceæ; >Hydrophyllaceæ, Boraginaceæ, Solanaceæ.

Sub-order Gentianales.

Families: Oleaceæ, Salvadoraceæ, Apocynaceæ, Asclepiadaceæ, Loganiaceæ, Gentianaceæ.

Sub-order Personales.

Families: Scrophulariaceæ, Orobanchaceæ, Lentibulariaceæ, Columeliaceæ, Gesneraceæ, Bignoniaceæ, Pedaliaceæ, Acanthaceæ.

Sub-order Lamiales.

Families: Myoporaceæ, > Selagineæ; > Verbenaceæ, Labiatæ.

ORDER CALYCIFLORÆ.

Sub-order Rosales.

Families: Rosaceæ, > Connaraceæ, Mimosaceæ, Cæsalpiniaceæ, Papilionaceæ; > Saxifragaceæ, Crassulaceæ, Droseraceæ, Grossulariaceæ, Bruniaceæ, Hamamelidaceæ, Platanaceæ.

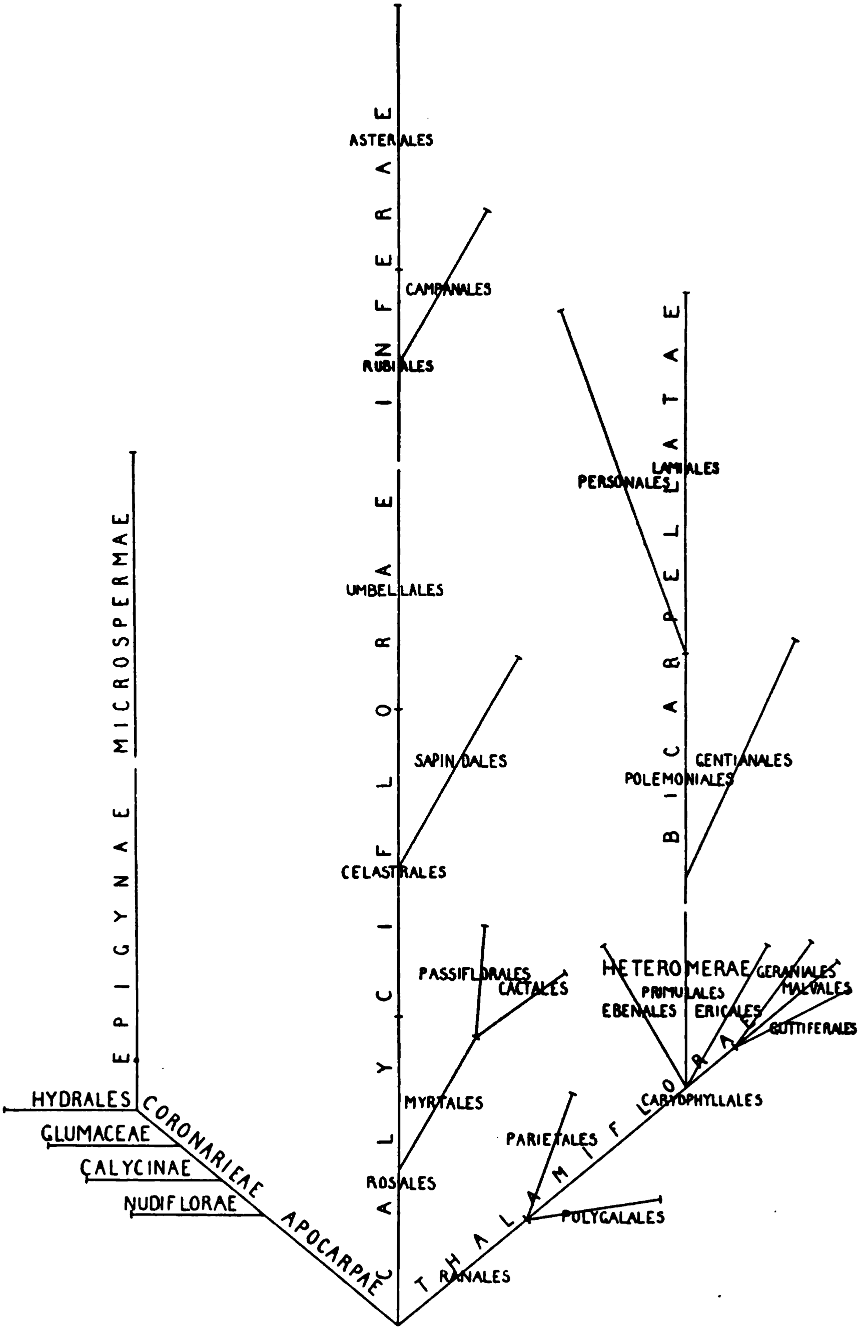

FIG. 3. Diagram to illustrate the relationship of the orders and sub-orders of angiosperms.

Sub-order Myrtales.

Families: Lythraceæ, > Melastomaceæ, Myrtaceæ, Combretaceæ, Rhizophoraceæ; > Onagraceæ, Halorageæ; > Aristolochiaceæ, Cytinaceæ

Sub-order Passiflorales.

Families: Loasaceæ, > Turneraceæ; > Passifloraceæ; > Cucurbitaceæ > Begoniaceæ, Datiscaceæ.

Sub-order Celastrales.

Families: Rhamnaceæ, > Celastraceæ, Stackhousiaceæ, Olacaceæ, Santalaceæ, Loranthaceæ, Balanophoraceæ; > Ilicineæ; > Vitaceæ; > Thymelæaceæ, Elæagnaceæ, Proteaceæ; > Penæaceæ.

Sub-order Sapindales.

Families: Sapindaceæ, > Sabiaceæ, Anacardiaceæ, Juglandaceæ; > Betulaceæ, Fagaceæ; > Myricaceæ; > Casuarinaceæ (?).

Sub-order Umbellales.

Families: Araliaceæ, > Umbelliferæ; > Cornaceæ.

ORDER INFERÆ.

Sub-order Rubiales.

Families: Rubiaceæ; Caprifoliaceæ.[17]

Sub-order Campanales.

Families: Campanulaceæ, > Goodeniaceæ, Candolleaceæ.

Sub-order Asterales.

Families: Valerianaceæ, > Dipsaceæ; > Calyceraceæ; > Compositæ.

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[17] It seems probable that the two families of Rubiales originated independently, the Rubiaceæ from Araliaceæ, and the Caprifoliaceæ from Cornaceæ.

BOTANICAL SOCIETY OF AMERICA.

THE third annual meeting of this society, held in the Biological Building of the University of Toronto, on Tuesday and Wednesday, August 17 and 18, 1897, was in many ways the most successful meeting which this young but vigorous organization has had. The attendance, although not large by reason of the absence of a number of members in Europe or the far west, was representative of Canada and states from New York to Nebraska; and the papers read touched almost every great department of botany except phytogeography. An inspection of the titles given below shows that teratology, physiology, morphology, cytology, histology, taxonomy, and bibliography were all under consideration. The open sessions on Wednesday for the reading of papers were attended by a considerable number of professional botanists from England, Canada, and the United States who expressed much interest and took part in the proceedings. As foreign associate members (for this meeting only) there were present Professor H. Marshall Ward, Professor F. O. Bower, Mr. Harold Wager, Mr. J. Bretland Farmer, and Mr. J. Reynolds Green.

The business meeting of the society was held on Tuesday afternoon at 3:00, following the meeting of the council in the Queen's Hotel at 1:30. The council reported that the mail ballots received had been opened and canvassed, and announced the election of the following officers for 1898: *President*, NATHANIEL L. BRITTON; *Vice president*, JOSEPH C. ARTHUR; *Secretary*, CHARLES R. BARNES; *Treasurer*, ARTHUR HOLLICK; *Councilors*, BENJAMIN L. ROBINSON and FREDERICK V. COVILLE.

The council, after careful consideration of the invitation of the director and trustees of the Missouri Botanical Garden to hold a spring meeting of the society in St. Louis as their guests, felt constrained to recommend that the invitation be regretfully

declined at present. The semi-centennial meeting of the A. A A. S., which is to be held in Boston next year, seems to make it imperative for the society to meet there in August in further ance of its plan to cooperate with the general association as fully as possible, and the close occupation of the members o. the society renders two meetings a year impracticable. In this recommendation the society fully concurred.

Other formal invitations from Omaha, Tampa, and Old Point Comfort were read, and the secretary was directed to send suitable replies conveying the thanks of the society for the invitations.

The proposition to amend the constitution so as to reduce the entrance and annual dues from $25 and $10, respectively, to $10 and $5 met with no favor. Communications to the secretary from members who could not be present, and the adverse opinions expressed at the meeting promptly determined the fate of the amendment. It was laid upon the table.

There was also before the society the proposal to establish one or two medals to be given at intervals for valuable research. The discussion of this topic showed the sentiment of the members to be rather in favor of allowing the funds of the society to accumulate until the interest is sufficient to be used in the promotion of research by the maintenance of a table at one of the biological stations. The proposition for establishment of a medal was therefore laid upon the table.

The programme of papers for Wednesday was announced The action of the council in inviting Mr. H. J. Webber to address the society upon his recent researches upon Zamia, and Drs MacDougal and Campbell to report their observations upon Jamaica as a site for a tropical laboratory, was approved.

On the second day at an executive session the following were elected active members: Bradley Moore Davis, of the University of Chicago; Sir John William Dawson, of Montreal; James Ellis Humphrey, of Johns Hopkins University; Daniel Trembley MacDougal, of the University of Minnesota; Frederick C. Newcombe, of the University of Michigan; Henry

Hurd Rusby, of the New York College of Pharmacy; Harry Luman Russell, of the University of Wisconsin; Joseph Newton Rose, of the United States National Museum; Walter Tennyson Swingle, of the Division of Physiology and Pathology, U. S. Department of Agriculture.

The address of the retiring president was delivered on Tuesday evening by Professor Dr. Charles E. Bessey, on "The phylogeny and taxonomy of angiosperms." It is printed in full elsewhere in this number.

The following papers were read on Wednesday:

B. L. Robinson: *A case of ecblastesis and axial prolification in Lepidium apetalum.* 10 min. (Published in full in this number.)

J. C. Arthur: *Movement of protoplasm in cœnocytic hyphæ.* 45 min.

The movement was first seen by the author in 1890, and has since been studied in eight species of Mucoraceæ. It resembles, but is not quite so rapid as the movement long known in the slime molds. The movement is best seen when the fungus is growing in a very moist atmosphere. The contents of the filament, including the large and numerous vacuoles, flow in a surging stream through the principal branches, more commonly toward the growing ends of the hyphæ and the forming sporangia. But the movement is inconstant, and is often reversed, or brought to a standstill, without any regularity. The author believes that the movement is due to the osmotic absorption of water in one part and the extravasation of water in a distant part. When the filaments are turgid this change of water content displaces the whole liquid mass from the place of greater tension toward that of lesser tension, producing a more or less uniform movement. The living protoplasm is, however, credited with being the exciting and controlling agent.

John M. Coulter: *Pollen grains and antipodal cells.* 30 min

Attention was called to the current views concerning the homologies of the pollen grain structures, and special objection

was made to the view which regards the pollen tube as the representative of the male prothallium. The recent discovery (in the author's laboratory) of the occasional occurrence of a small lenticular cell, cut off before the usual divisions of the microspore nucleus, and also of the occasional direct division of the "vegetative" nucleus, suggest again the older homologies. Comparison with the corresponding structures of heterosporous pteridophytes suggests that the occasional lenticular cell cut off in the germinating pollen grain represents the "prothallial" cell which constantly appears in the former, and that the pollen grain as a whole, with the exception of this occasional cell, represents the single antheridium of the heterosporous pteridophytes. According to this view the "vegetative" nucleus, with its cytoplasmic organization, represents the antheridium wall, from which the pollen tube is an outgrowth. The so-called "male cells" would thus represent the spermatozoid mother cells of the heterosporous pteridophytes.

In connection with the antipodal cells attention was called to the fact that they represent the most variable region of the embryo sac in dicotyledons, in which four types of antipodal development were noted: (1) a group of evanescent cells, usually three in number, characteristic of Amentiferæ and their allies; (2) three large antipodal cells, increasing in size with the sac, apparently very active, and usually becoming multinucleate, characteristic of Ranunculaceæ and their allies: (3) usually three comparatively permanent cells, not notable in size or activity, rather common among Sympetalæ; (4) an indefinite number of cells, forming a relatively permanent and very prominent tissue, often continuing its growth downward and breaking through the bottom of the sac, very characteristic of certain sections of the Compositæ.

FREDERIC E. CLEMENTS: *The transition region of the Caryophyllales.* 30 min. Presented by CHARLES E. BESSEY.

The history of the investigation of the transition region was discussed at considerable length. After a concise sketch of the histogenetic changes in the transition region in general, the

details of the process were given for selected genera, Dianthus, Portulaca, Allionia, Phytolacca, Polygonum, and Rumex. The author's résumé is as follows: Three types of transition may be distinguished with respect to the constitution of the bundle trace of the cotyledons; holostelar, where the trace is composed of the entire vascular system of the hypocotyledonary stele; prototracheidal, when the prototracheids are the xylem elements to pass into the cotyledons; metatracheidal, when the cotyledonary trace is formed by the metatracheids. With reference to the perfection of the transition in the hypocotyl, the transition may be truncate, or complete. In the first case, the xylem and phloem reach the cotyledons in centripetal, or secantial orientation; in the second, the orientation is centrifugal, and the stele becomes collateral.

D. P. PENHALLOW: *A revision of the species of Picea occurring in northeastern America.* 25 min.

The author reviewed the relations of the spruces of northeastern America with special reference to the possible separation of the red spruce as a distinct species. In 1887 the late Dr. George Lawson advocated the separation of the red from the black spruce with which it has been merged for the last seventy years, or since the time of Pursh. A critical study of authentic material, both in the field and in the laboratory, leads to the conclusion that the red spruce possesses well defined specific characters which separate it from all others. This evidence is derived primarily from the cones and leaves, but is supported by data derived from the internal structure of the stem. It is also highly probable that there may be another, and heretofore unrecognized variety or species of spruce closely allied to the black spruce, but further study in this direction is needed

The author also recognizes a well defined variety of the white spruce, locally known as the cat or skunk spruce, for which he proposes the name *fœtida* in allusion to its characteristic odor.

EDWARD LEE GREENE: *Bibliographic difficulties.* 30 min.

The author cited numerous instances of the complexity of

the so-called species of Linnæus, and consequent impossibility of determining to which of the segregates a given specific name ought to be applied. Thus, out of the *Viola palmata* of that author, or, at least, out of plants all answering about equally well to his brief and vague diagnosis, no less than five thoroughly distinct segregate species are recognized by botanists who know the east American violets. Meanwhile it is certain that even the synonyms by Gronovius and Plukenet, adduced by Linnæus as all three being equivalents of his *V. palmata*, themselves represent three distinct violets; and the question was raised as to whether in cases like this the Linnæan specific name ought not to be abandoned altogether, seeing that he applied it to no species, but to a group of species, and that the name befits no one of the five or six better than the others. European botanists have frequently taken such a course in dealing with such groups of species which Linnæus had mixed together under one specific name so-called. The eighteen species of North American asters named, and more or less imperfectly published by Linnæus in 1753, were discussed as being in several instances indeterminable. Scarcely one out of the eighteen is adequately described, and the greater part of those which the most critical and careful specialist finds himself able to make out, he identifies, not from Linnæus, but from those pre-Linnæan authors whom Linnæus cites as having published fuller descriptions than his own, these often accompanied by plates or figures of the species. Since many hundreds of the Linnæan plant-species are only to be identified at second-hand, by help of the references which he is constantly making to Dodonæus, Ray, Morison, Dillenius, and other earlier authors, the real identification, by Linnæan name, of a host of our species, is accomplished by a study of those authors rather than by reading the short and often nearly useless diagnoses in those little volumes of the year 1753. The paper concluded in a note of warning to those of our younger botanists, who, while accomplishing much excellent phytographic work in the discrimination of species hitherto long confused, and publishing

excellent monographs as to knowledge of the plants, are evading the bibliographical difficulties, taking little or no care to ascertain whether the form which they publish for a new one be not in reality the old type, thus taking continual risk of adding to that nomenclatorial confusion which they are endeavoring to disentangle.

WILLIAM FAWCETT: *The botanic gardens of Jamaica.*

Mr. Fawcett expected to be present, but was unable to obtain leave of absence, and forwarded the paper, with lantern illustrations, to the president, Professor J. M. Coulter. Unfortunately the paper did not reach its destination, and it was therefore read by title only. The council had invited Drs. D. T. MacDougal and D. H. Campbell to address the society in connection with this paper, giving an account of their investigation this summer of Jamaica as a site for the proposed tropical laboratory.

Professor MacDougal discussed the physical features and climate of the island, while Professor Campbell summarized the botanical features. These accounts were listened to with greatest interest, and many questions were asked, which showed the eagerness with which American botanists are looking forward to the foundation of this laboratory. All the facts will be presented later when the other commissioners visit this and other islands in the course of the coming winter.

HERBERT J. WEBBER: *Researches upon Zamia.*

By invitation of the council, Mr. Herbert J. Webber addressed the society upon his recent researches upon Zamia, which have brought to light the remarkable results, some of which have already been published in this journal, and of which a complete account will appear herein later. Mr. Webber traced the development of the megaspore and microspore, the formation of the spermatozoids, their movements and union with the egg nucleus. He also called attention to the two forms of Zamia which he has observed, and showed cones of both sorts, which he thinks are entitled to separation, varietal, or possibly specific. The existence of these gigantic spermatozoids (visible

to the naked eye!) is almost incredible until one inspects Mr. Webber's preparations, which he exhibited later to members The research not only shows many new points but opens collateral questions of great import. The exceptional interest attaching to these discoveries amply justifies the praise which Mr Webber is receiving.

ABSTRACTS OF BOTANICAL PAPERS READ AT THE DETROIT MEETING OF THE A. A. A. S.

THE following papers were presented before Section G, and in most cases the abstracts are those prepared by the author. The vice presidential address of Professor George F. Atkinson, entitled "Experimental morphology," is published in full elsewhere.

CHARLES A. DAVIS; *Trillium grandiflorum* (Michx.) Salisb.*; its variations normal and teratological.*—The variations are largely of a type common to most species of plants, in the shapes of leaves, petals, and sepals, and in the varying length of petioles. In several hundred abnormal specimens the simplest departure was marked by the presence of green stripes in the petals. This striping was accompanied by lengthening of the petioles and degeneration of the pistil. About fifty specimens were studied in which the leaves had either entirely disappeared or were reduced to bracts. In such forms the stamens are the most stable of the organs of the flower, only a few reversions to the leaf type occurring, while the pistil was usually sterile, rarely containing ovules, frequently being reduced to the leaf form, and sometimes containing well marked whorls of leaves. The petals of this form were usually nearly all green. Variations from the normal form of rootstock, and in the number of parts in each whorl of the plant to two and four, were also noted.

E. J. DURAND: *A discussion of the structural characters of the order Pezizineæ of Schroeter.*—Read by title.

K. M. WIEGAND: *The taxonomic value of fruit characters in the genus Galium.*—In certain species of Galium the fruit is saucer shaped, in other closely related species cup shaped, and in others the edge of the cup is so constructed as to leave but a pore connecting the hollow interior with the exterior.

CHARLES E. BESSEY: *Report upon the progress of the botanical survey of Nebraska.*—The survey was organized in 1892 by the Botanical Seminar of the University of Nebraska, since which time it has brought together more than 10,000 specimens; published "Reports I, II, III, and IV;" and published Parts I, II, and XXI of the *Flora of Nebraska.* The total number of species known to the state is about 3400.

ALBERT F. WOODS: *Bacteriosis of carnations.*—This disease is not due to a bacterial disease, as has been supposed, but to the punctures of aphides and thrips. The cells affected become œdemic, collapse, and give a whitish sunken spot. The dead tissue may subsequently become infested by bacteria and fungi. (Published in full in this number.)

ERWIN F. SMITH: *Wakker's hyacinth bacterium.*—Diseased bulbs were procured in 1896 from the Netherlands, and the whole subject has been re-examined. The micro-organism described by Dr. Wakker in 1883 as *Bacterium hyacinthi* is the true cause of the disease, and is quite unlike that subsequently isolated from rotting hyacinth and described by Dr. Heinz as *Bacillus hyacinthi septici.* Successful inoculations have been obtained from pure cultures, and much new information has been gathered respecting the relationships of the organism and its behavior in a variety of culture media.

CHARLES E. BESSEY: *Are the trees receding from the Nebraska plains?*—None are known to be receding, while several species, such as the bur oak and the pines are advancing.

C. A. PETERS: *Reproductive organs and embryology of Drosera.*—A detailed account of the structure and development of pollen and ovule, the former differing in some particulars from that of most dicotyledons.

J. O. SCHLOTTERBECK: *Development of some seed coats.*—The appendage to the seed of *Melampyrum pratense* is not a strophiole, nor a caruncle, nor an arillus, each of which has been claimed, but is a part of the endosperm which becomes constricted off from the rest during development. A study of the development of the seed of *Croton Tiglium* shows that its nucellus protrudes far

out of the micropyle, the only similar case known being that of *Croton flavens*.

J. H. SCHUETTE: *Contributions on wild and cultivated roses of Wisconsin and bordering states*.—Read in abstract.

FANNY E. LANGDON: *Development of the pollen of Asclepias Cornuti*.—In this study the order of cell formation has been verified by nuclear figures, thus removing all doubt with regard to successive changes. The order of development differs from the account given by Corry, the only previous writer, in the following particulars: (1) the archesporium, as in most dicotyledons, is composed of a layer of cells, and not of a single column of cells, as stated by Corry; (2) the tapetum from an early stage is composed of two to several layers, instead of a single layer; (3) Corry states that the wall of the tapetum next to the pollen becomes chitinous, and that this changed wall forms the outer wall of the pollinia, while the latter is found by the present writer to be derived in part from a secretion from the tapetum and in part from the changed outer walls of the pollen cells. The cells of the tapetum undergo remarkable changes during the development of the pollen, and probably function as glandular tissue, manufacturing a secretion which is to serve as protection to the pollen, rather than "breaking down."

CHARLES E. BESSEY: *Some characteristics of the foothill vegetation of western Nebraska*.—The foothill region is an elevated plain 1200 meters above sea level, upon which are Pine ridge on the north, 1500 meters above sea level, and Cheyenne ridge on the south, 1700 meters above sea level. Upon Cheyenne ridge occur considerable bodies of trees, mostly pines, with red cedar, box elder, and others. The Box butte plains are covered with a uniform grass formation.

H. F. OSBORN and E. B. POULTON: *Organic selection*.—Suggestions regarding the harmonizing of Darwinism and Lamarckism proposed by Professor Osborn were criticised by Professor Poulton.

JAMES B. POLLOCK: *Mechanism of root curvature*.—From experiments continued during two years it is held to be demon-

strated that the stimulus, in response to which curvature takes place, is transmitted in the cortex, either of the convex or concave side, and that the root in curving takes advantage of tensions already existing. In an unstimulated root the tissue tensions are such that every side tends to curve the root away from that side. These tendencies balance each other and the root grows straight. When the root is stimulated (as by wounding one side of the tip) an impulse is transmitted along the cortex as far as the curvature extends. The impulse produces on the side farthest from the wound a change in the protoplasm of the cortical parenchyma which makes it more permeable to water. The elasticity of the cell walls forces water out of the cells into the intercellular spaces. This shortens the cells of that side. At the same time the stimulus causes an extension, probably a growth, of the cells on the side that becomes convex. Both sides of the roots are active in producing the curvature, but their activities are of a different kind. The axial cylinder remains neutral and curvature necessarily follows.

FREDERICK C. NEWCOMBE: *Cellulose ferment.*—Account of the action of a cellulose dissolving enzyme extracted from cotyledons of seedlings of *Lupinus albus.*

RODNEY H. TRUE and C. G. HUNKEL: *The toxic action of phenols on plants.*—A study of the toxic action of phenols on living plants shows that they act less sharply and less severely than acids and heavy metals. Electrolytic dissociation plays a much less active rôle, generally speaking, than is the case in those classes of compounds, the toxic effect being due in the main to the undissociated molecules. Various radicals, when introduced into the molecule, exert a specific effect. The number of OH groups present, from one to three, does not directly affect the toxic action of phenols. The introduction of an OCH_3 group does not increase the toxic action of phenols. The introduction of one or more NO_2 groups, the substitution of a CH_3 group for an OH group, the presence of a C_3H_7 group or a COOH group, all increase in some measure the toxic action of the substance It seems certain that when plants are raised under constant con-

ditions their protoplasm with much constancy gives results which depend on the nature of the solution used, and stand in direct relation to its chemical composition.

CHARLES PORTER HART: *Is the characteristic acridity of certaiu species of the arum family a mechanical or a physiological property or effect?*—Preparations of the extracted juice of arum that have been filtered still preserve their acridity and produce remarkable physiological effects.

W. J. BEAL: *How plants flee from their enemies.*—It is found impossible in many cases to maintain beds of a given species for any considerable length of time in the place where they were originally set on account of various enemies from which the plants either slowly or rapidly withdraw. Water plants also exhibit peculiar habits in this respect. *Marsilia quadrifolia* has been observed to grow at different levels and in different ways, following changed external conditions.

ALEX. P. ANDERSON: *Stomata on the bud scales of Abies pectinata.*—Heretofore stomata have been thought never to occur on the bud scales of gymnosperms. They are now found on those of the species named.

ALEX. P. ANDERSON: *Comparative anatomy of the normal and diseased organs of Abies balsamea affected with Æcidium elatinum.*—Comparison shows differences in structure of leaves of the lateral and erect branches; the presence of two to six resin canals in the diseased bud scales, from which the resin, exuding through fringing hairs, spreads in a layer 1 to 3^{mm} thick over the scale; and the formation of resin vesicles in the primary cortex by the growth of the epithelial lining to the resin canals.

ALEX. P. ANDERSON: *On a new and improved self-registering balance.*

CHARLES O. TOWNSEND: *The correlation of growth under the influence of injuries.*—The purpose of the experiments conducted by the writer was to determine in what time, through what distance, and to what extent an injury inflicted upon one part of a plant will influence the growth of the injured and also of the uninjured parts. Seedlings were chiefly employed, but older

plants were used to some extent, as was also *Phycomyces nitens*. The flowering plants were injured by removing the roots as a whole or in part, or by splitting the roots near the base or near the tip; or the shoots or leaves were removed as a whole or in part. Specimens of Phycomyces were injured either by cutting away a mycelium or by removing one of the two or more sporangium stalks. In the case of the higher plants a gradual change in the rate of growth took place, and became marked in from six to twenty-four hours after injury. The influence of the irritation extended through a distance of from 0 to 300^{mm}, although this is by no means considered to be the limit through which the influence of injury is capable of acting. The change in rate of growth after injury varied from 0 to 80 per cent. of the normal rate. In the case of Phycomyces the rate of growth was reduced immediately after injury, and recovered its normal rate in from thirty to sixty minutes. In no case examined did the growth entirely cease.

W. W. ROWLEE and K. M. WIEGAND: *The botanical collection of the Cornell Arctic Expedition of 1896.*—Read by title.

ERWIN F. SMITH: *Description of* **Bacillus phaseoli,** n. sp.—*Bacillus phaseoli* is a short rod with rounded ends, yellow on various media, motile in early stages of growth, and decidedly pathogenic to beans and some related legumes, causing water-soaked spots on the pods. Its thermal death point (ten minutes exposure) is approximately 49° C., and it will not grow in the closed end of the fermentation tube with any of the common sugars. This organism is closely related to *Bacterium hyacinthi* Wakker and *Bacillus campestris* Pammel, two other motile yellow germs. It has been under observation in pure cultures for about thirteen months, and there is no doubt whatever as to its parasitic nature, all of Koch's canons for determining this point having been complied with. The three organisms here mentioned were compared and contrasted, and cultures of each exhibited, also photographs, paintings, and dried specimens.

ERWIN F. SMITH: *On the nature of certain pigments produced by fungi and bacteria, with special reference to that produced by*

Bacillus solanacearum.—The dark brown pigment produced by the potato rot bacillus will not dialyze, or does so only very imperfectly, and is precipitated by compounds of calcium and of iron. It was suggested as a working hypothesis that the humus compounds of the soil are due solely to the chemical action of fungi and bacteria on the carbohydrate materials of animals and plants, especially the latter.

ON SOME ALGAL STALACTITES OF THE YELLOWSTONE NATIONAL PARK.

JOSEPHINE E. TILDEN.

(WITH PLATE VIII)

DURING the summer of 1896, while making a collection of algæ living in the hot waters of Yellowstone Park, a curious phenomenon of algal growth was observed which, it is thought, is worthy of being recorded. It was the production by certain species of algæ of thalloid structures which, both from their appearance and their method of development, may be termed stalactites.

The most characteristic forms noticed occurred in a small cave made by the cone of a geyser. The entire inner surface of the roof was coated with the algæ, which formed shining black sheets or pendant masses of true stalactitic appearance (*fig. 1*). They looked not unlike a group of icicles depending from some ledge. Indeed, the arrangement of the grouping was quite similar, but as far as individual shape is concerned the algal thalli were much shorter, thicker, and more broadly conical than the common icicle form. Then, too, this typical shape showed variation in two directions. Many were mere knob-like processes, as large as one's fist, perhaps, while some formed masses of small, fleshy, toothed appendages. The plants chiefly concerned in the building up of these stalactites were *Schizothrix calcicola*, *Glœocapsa violacea*, and *Synechococcus aeruginosus*.

In order to explain the probable cause of this formation, it will first be necessary to call attention to a peculiar method of growth which characterizes species belonging to the group Oscillarieæ, and then to describe a little more fully the habitation of the algæ in question.

It is well known that when a bit of living Oscillatoria, Phor-

midium, or the like, is placed in a drop of water spread out on a surface, as on a mounting card, the filaments move away from each other so that they come to occupy the entire drop. In this moving about they arrange themselves in somewhat radial lines. This behavior on the part of these plants is frequently made use of in the preparation of dried mounts. A bell jar is placed over the card on which is the drop of water containing the algæ. This prevents evaporation for a few hours, which is as long as the filaments remain in action. When dried in this way the plant shows to very good advantage its texture and color.

The geyser in which the stalactites were found was situated on a knoll near the summit of a hill. Generally, the vent of a geyser occupies the center of the built-up cone. In this case the aperture was in the side of the cone, the center of which was entire and mound-shaped. This resulted in there being formed a cavity a foot or two in diameter and winding or irregular in shape. Since the opening was near the base of the cone, and small in comparison with the size of the cavity, only a limited amount of light could reach the interior. The geyser spurted hot water almost continuously, but in small quantities, which may have reached a height of a foot or two, had it not been intercepted by the dome of the deposit. As it was, the water struck the ceiling of the dome and most of it trickled back into the pit. A small stream of hot water issued from the vent with jets of steam.

The action of a geyser may undergo frequent change during its period of existence with regard either to the force exerted in projecting the water, or to the amount of water thrown off at an eruption, or to the length of the interval between eruptions. Consequently, it is reasonable to suppose that this particular geyser at some previous stage projected its stream of water to a less height than at present, that is, so that it did not come in contact with the dome. The steam, under such circumstances, would have condensed on the cold surface of the ceiling of the dome, forming drops of water which evidently would not have quickly evaporated, since they were kept in a moist atmosphere

and frequently reinforced by other condensations of steam. A place of abode of this kind, providing shade, protection, and constant moisture in small quantity, would favor the growth of such an alga as Schizothrix.

It is thought that the movement of the filaments produced in the drop of water on the mounting card is exactly what takes place in the drops of water suspended from the ceiling of the cave. These not being allowed to evaporate are soon so crowded with the rapidly growing filaments that the shape is permanently retained. Other drops are added, the alga grows into them, and a stalactite is built up. And thus, as it is not difficult to understand, the process of formation of mineral and algal stalactites is quite homologous.

In attempting to understand what must have been the past history of this algal colony, in order to account for the new form taken on by the thallus, one meets with a second problem of interest, that is, the adaptation of the algæ to their peculiar environment. Thus, (1) the algal structure is accustomed to a state of semi-darkness; even in bright sunlight the entrance of more than a small amount of diffused light into the cavity is prevented, and direct light is never possible. (2) It depends for its supply of moisture entirely upon that afforded by the eruption of the geyser. While the material that forms the cone of the geyser is of such nature that moisture can percolate through it, the fact that it is higher than the surrounding ground would leave it without opportunity for collecting moisture either in the form of rain or from underground springs. (3) It accommodates itself to the action of hot water, hot air, steam, and cold air. These forces operate at irregular but short intervals of time. (4) Accordingly, the growth is neither strictly aerophytic nor hydrophytic, but partakes of both characters.

The temperature of the hot air or steam in the upper part of the cavity was found to be 81° C., and this was probably the average temperature. Owing to the sudden bursts of steam and hot water, it was with much difficulty that a supply of the material could be secured. The greater part of this was dried

at once. Some which showed well the characteristic shape was preserved in a solution of formalin for study in the laboratory.

When first collected the algal growth showed the following features: The stratum was firm in substance; the entire surface of the sheet, teeth and stalactites was protected by a thin black membrane, fine in texture, smooth and shining; the inner parts were somewhat spongy, yet firm, and in color white, gray, or brownish, with violet, rose and blue-green tints in places. In making a cross section of a stalactite a laminated appearance was noticed (*fig. 2*). The lamellae were numerous and very thin. Some of the most perfectly formed stalactites, though not the largest, measured from 5–8^{cm} in length and 1.5–2^{cm} in diameter.

Upon returning to Minneapolis, a microscopic study of the formalin material showed that there were present a group of algae of which three members were constant. These were *Schizothrix calcicola*, *Glœocapsa violacea*, and *Synechococcus aeruginosus*, of which the following are descriptions based upon the Yellowstone material.

SCHIZOTHRIX CALCICOLA (Ag.) Gomont Monographie des Oscillariées, Ann. Sci. Nat. (Bot.) VII. **15**: 307. *pl. 8. fig. 1–3.* 1892. Tilden, Am. Alg. Cent. II, no. 180. 1896. (*Plate VIII, figs. 3, 4.*)

Stratum not encrusted with lime, somewhat gelatinous, very hard when dried, membranaceous, black or dark violet. Filaments strongly and sharply bent, interwoven; sheath firm, straight, in the beginning somewhat narrow, cylindrical, including one trichome, with age growing thicker, becoming somewhat lamellose, including two to many trichomes; trichomes pale aeruginous (after remaining in formalin several months), neither attenuate nor curved at the apex, not constricted at the dissepiments, 1.6μ in diameter; articulations in general 1–2 times longer than the diameter; apical cell rotund; dissepiments marked by protoplasmic granules.

It is the interwoven filaments of this plant alone which form the membrane of the stalactite. Empty sheaths are also present in great abundance throughout the whitish or light-colored interior.

It is necessary at this point to correct a mistake made in labeling the above species in *American Algae*, Century II. When the algae were first studied, before distributing them, although careful examination was made of various portions of the formalin material, it happened that no sheaths were found containing more than a single trichome. This made the plant appear very much like *Phormidium purpurascens*, as may be understood by referring to Gomont's description, and it was placed under this name. Later investigations have shown clearly that the Phormidium-like simple filaments are but young stages of *S. calcicola*.

SYNECHOCOCCUS AERUGINOSUS Naeg. Einz. Alg. 56. 1849.

Cells 3.2–8μ in diameter, spherical or oblong, aeruginous, with thin sheath, for the most part solitary but at times four or five joined in a pseudo-filament. (*Plate VIII, fig. 6.*)

With the lower power of the microscope these cells are readily seen, as they occur for the most part in heaps or masses and are bright blue-green in color. They are found only in the interior of the thallus.

GLŒOCAPSA VIOLACEA (Corda) Rabenh. Fl. Eur. Algar. 2:41. 1865. (*Plate VIII, fig. 5.*) Forming the reddish or grayish violet portions of the interior of the thallus, mucilaginous; cells globose, 6.4–14.4μ in diameter; tegument not lamellose; cytoplasm aeruginous, granulate. These cells, for the most part empty and colorless, are very numerous throughout the interior portions of the structure.

Valley of the Nez Perces creek, Lower Geyser Basin, Yellowstone National Park. June 29, 1896.

Another species belonging to this group, *Phormidium laminosum*, is exceedingly abundant in the hot waters of the Park. In its normal condition it forms wide sheets, delicately granulose in substance, of no definite shape. It also formed hollow strings (suggesting a Tetraspora growth) rising from the bottom of hot springs and expanding at the surface into flat or bulbous masses. In a few instances it formed long narrow appendages supported by submerged grass stems (*figs. 7–8*). It is probable that

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these were formed in a similar manner to the stalactites already described. The stems must have first been out of the water, however, to allow the steam to condense on them. Afterwards the weight of the stalactites would draw them into the water. One of these stalactites preserved in formalin shows a length of 45^{mm}, a maximum width at the base of 12^{mm}, and a minimum width at the tip of 6^{mm}. It is abruptly truncate at the tip, and is covered with a delicate green membrane, while the inner parts are lighter or whitish in color. In most cases these pendants formed a hollow tube closed at the tip.

UNIVERSITY OF MINNESOTA.

EXPLANATION OF PLATE VIII.

Fig. 1. View of stalactites *in situ*, natural size.

Fig. 2. Cross section of a stalactite showing lamellae and hollow central portion.

Fig. 3. Young filaments of *Schizothrix calcicola.*

Fig. 4. Filament of same in later stage, with sheath containing two trichomes.

Fig. 5. Cells of *Glœocapsa violacea.*

Fig. 6. Cells of *Synechococcus aeruginosus.*

Fig. 7. Stalactite formed by *Phormidium laminosum.*

Fig. 8. Filament of *Phormidium laminosum.*

"BACTERIOSIS" OF CARNATIONS.[1]

ALBERT F. WOODS.

DURING the past two or three years the writer has had under investigation a disease of the Bermuda, or Easter lily. Early in the course of this work it was observed that the disease of the lily possessed certain characteristics in common with one affecting carnations, first described by Dr. J. C. Arthur in a paper[2] read at a meeting of this association at Toronto, August 1889. Through this paper and the publications of Dr. Arthur[3] and of Arthur and Bolley,[4] the disease has come to be generally known as "bacteriosis" of carnations. In connection with the work on the lily disease,[5] "bacteriosis" of carnations has received considerable attention during the past year, and the object of this paper is to review briefly some of the results obtained.

For a general description of the disease the following, quoted from the bulletin by Arthur and Bolley already cited, covers the ground thoroughly:

Bacteriosis is a disease of the carnation leaf, rarely attacking the stem or other parts of the plant. It generally starts in the leaf when immature, and is best diagnosed in the younger but full-sized leaves nearest the upper end of the stem. Taking such a leaf, which on its surface presents no unusual appearance to the eye, and holding it toward strong light, small, pellucid dots may be detected scattered irregularly through the leaf, sometimes having a faint yellowish color, which are the centers of infection. The appearance of the dots has a close resemblance to those of the oil glands in the leaves of the common St. John's wort (*Hypericum perforatum*), a rather abundant weed

[1] Read at the meeting of the Amer. Ass'n Adv. Sci., Detroit, Mich., August 1897.

[2] J. C. ARTHUR, Proc. Amer. Ass'n Adv. Sci. **38** : 280. 1889.

[3] J. C. ARTHUR, Amer. Florist **6** : 419. 1891; Rep't Amer. Carnation Soc. 52. 1892; Rep't Amer. Carnation Soc. 12. 1894; Amer. Florist **9** : 467. 1894.

[4] ARTHUR and BOLLEY, Purdue Univ. Agr. Exp. Sta. Bull. no. 59. 1–38. *pl. 8.* 1896.

[5] The lily disease has been fully discussed in a bulletin soon to be issued by the Division of Vegetable Physiology and Pathology, U. S. Department of Agriculture.

or in the leaves of the false indigo (*Amorpha fruticosa*), a native shrub, except that they have no regular disposition. Sometimes the surface of the leaf is slightly raised over the dots, making watery pimples.

After a time the surface of the leaf above the dots changes enough to indicate their presence, and finally shows a distinct spot. As the disease extends inside the leaf the surface tissues collapse and whitish sunken spots appear. In some colored varieties of carnation the spots vary somewhat by being more or less reddish or purplish. As the spots increase in size the leaves wither, still clinging to the stem. Such spots never show distinct darker colored specks and rarely any concentric circles, as do the spots made by parasitic fungi, such as Septoria (spot disease) and Heterosporium (fairy ring).

Very badly diseased plants, especially when much crowded and growing in damp atmosphere, have more yellowish green leaves than normal, of a more transparent appearance, and usually smaller. The lower leaves of diseased plants in any atmosphere or soil die prematurely and the vitality of the plant is so lowered as to check the growth and decrease the size and number of the flowers.

Arthur and Bolley find that "no varieties of the carnation are exempt from the disease, but they differ much in susceptibility. The seat of this difference is chiefly in the vigor of the plant. . . . . Poorly grown plants are more affected than those well grown. Partly starved or stunted plants are specially liable to attack." They found the disease at Indianapolis, La Fayette, and many other places in Indiana, and in Buffalo, Boston, New York, Toronto, Chicago, and Lincoln. They say it is common throughout eastern North America wherever carnations are grown extensively, and conclude that it is caused by "parasitic bacteria entering the plant from the air through the stomata, or occasionally through the punctures of aphides."[6]

The disease which has formed the subject of our studies agrees in all essential points with the one just described, except that it is not caused by bacteria. Our material was obtained from many of the large centers of carnation growing in the United States, and through the kindness of Dr. Arthur good specimens were recently sent in from Mr. Fred Dorner's place at La Fayette, Ind.

[6] ARTHUR and BOLLEY, *loc. cit.* 32 and 37.

METHODS OF STUDY.

Microscopic investigations.—Material showing various stages of the disease was killed by both the chromic acid and absolute alcohol methods, dehydrated with alcohol, and infiltrated with paraffin in the usual way. Microtome sections were then cut and mounted in series, and these were stained with Ziel's carbol fuchsin, and, according to Gram's method, with anilin water gentian violet. The cells of the diseased spot were found to be much larger than normal, thin-walled, and oedemic. The chloroplasts were smaller than in healthy cells and were colorless or yellowish. Even after the most thorough and careful staining no parasitic or saprophytic organism could be detected in the tissues of these spots before the epidermal cells collapsed. In some cases after they collapsed fungi and bacteria were readily distinguished.

Cultures.—After many trials by washing and flaming it was found to be impossible to free the surface of a carnation leaf from outside germs by any means which might not also destroy germs in the tissues. Cultures were therefore made from the diseased mesophyll direct by very carefully peeling off the epidermis and scraping out the inner tissues with a flamed scraper which had been allowed to become perfectly cool. From one to twenty spots, varying in size from 0.5^{mm} to 2^{mm} in diameter, were included in each culture. Altogether about 500 cultures were made in various media, such as slightly acid, neutral, and slightly alkaline beef broth, with and without peptone; potato broth of various strengths; cauliflower broth; potato cylinders; agars of various composition; gelatin, acid, neutral, and alkaline to litmus, etc. In no case were organisms found in any culture made from a spot before the epidermal tissues had collapsed In cultures made from spots which had collapsed various fungi and bacteria were occasionally obtained, but not constantly or always of the same sort. Cultures including the epidermis frequently contained various organisms, among which was a yellow bacterium which occurred frequently on the surface of both dis-

eased and healthy leaves, and which resembled in many respects the organism described by Arthur and Bolley as *Bacterium dianthi*, the cause of "bacteriosis." Infection experiments were made with this and other organisms, but the disease was not produced in any case.

From this work and the fact that no fungi or bacteria whatever were found associated with the disease in its earlier stages we were led to look in other directions for the cause.

RELATION OF APHIDES AND THRIPS TO THE DISEASE.

Aphides.—Early in the work our attention was called to the manner in which aphides attack the plant. A careful study revealed the fact that the insects in question were seldom if ever absent from plants, and that when present in limited numbers they were capable of producing effects identical in every way with those described under the name of "bacteriosis."

Studies of serial sections of spots produced by the aphides showed a breaking or laceration of the mesophyll cells, extending from the epidermis to various depths into the leaf. Oedemic swellings start from these points, resulting eventually in the development of all the characteristic symptoms described. Colonization experiments with the aphides were repeatedly made and it was found that the insects alone were capable of producing the disease and that neither fungi nor bacteria were present until the malady was well advanced, and in such cases not regularly nor constantly. In the colonization work it was found that the insects crawl between the young leaves on the growing shoots and do most of their work where they cannot be reached by tobacco smoke in sufficient strength to kill them. It was further found that it takes about two weeks for a puncture to become visible to the naked eye, appearing first as a minute translucent dot, accompanied by slight swellings of the tissues. Severe cases of the trouble were produced in perfectly healthy plants by colonizing the insects upon them, and the new growth of badly diseased plants was kept entirely free from the malady by eliminating the aphides and other puncturing insects. These

results were obtained repeatedly in the laboratory and in the greenhouse.

Thrips.—Another form of spotting, usually accompanied by distortion of the young leaves and often of the stems, was found to be produced by thrips. These spots can be readily distinguished from the work of aphides, being very irregular in shape and having mossy outlines. The changes produced in the cells of the leaf, however, are apparently the same as those brought on by aphides, except that the mesophyll cells are not lacerated. Sections and cultures were repeatedly made from such spots produced under our control, but no organisms were obtained from the mesophyll in any case.

Throughout the work it was found that certain varieties of carnations were much more subject to the attacks of both aphides and thrips than others. Susceptibility was found to depend more upon the inherent characteristics of the individual plants than upon the variety. In most cases, however, susceptibility to attack is the direct result of improper methods of cultivation This is only expressing in another way a fact already well recognized by carnation growers, namely, that the disease under consideration is one which in most cases can be readily controlled by care in the selection and propagation of stock and attention to all the details of cultural conditions.

Summarizing it may be said that

1. The disease of carnations characterized by the symptoms already described and generally known as "bacteriosis" is wide spread and destructive.

2. In the earlier stages of the disease neither fungi nor bacteria are present, so far as can be determined by the most careful microscopic studies and bacteriological investigations.

3. As the disease advances various organisms appear, but their presence is not constant.

4. Infection experiments with such organisms, carried on under rigid bacteriological conditions, resulted negatively in every case.

5. A disease having all the characteristic symptoms of "bac-

teriosis," excepting the presence of bacteria, is produced by the puncture of aphides, as was repeatedly proved by the colonization of these insects on the plants.

6. That the aphides alone are responsible for the trouble is shown by the fact that the injuries produced are not accompanied in the earlier stages by fungi or bacteria. The aphides, therefore, can not be looked upon as carriers of any fungus or germ.

7. Injuries similar in many respects to those produced by aphides also result from the attacks of thrips, an insect nearly always present on carnations under glass, although generally overlooked by growers.

8. The carnation is a plant readily influenced by the conditions under which it is grown, and as a result the reaction to the injury of the aphides and the susceptibility to their attacks not only vary with varieties, but with individuals of the same variety. Plants, therefore, grown under improper conditions will show more of the characteristic injuries from a given number of aphis punctures than those where all the conditions have been favorable for growth.

9. Proper selection and propagation of stock; furnishing soil, moisture, light, and air best adapted to healthy and vigorous growth; and keeping down to a minimum the number of aphides and thrips will enable the grower to successfully combat the disease.

DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY,
U. S. DEPARTMENT OF AGRICULTURE.

BRIEFER ARTICLES.

A METHOD OF PRESERVING THE GREEN COLOR OF PLANTS FOR EXHIBITION PURPOSES.

For many purposes, especially when intended for museums, classes in botany, pharmacy, etc., it is very desirable to preserve, as far as possible, the natural appearance of plant specimens. Where the purposes for which the material is to be used will permit its preservation in a dry state, the natural colors may generally be well preserved for some time by rapid drying. This is true of nearly all colors both of leaves and flowers. Such material, however, is likely to slowly fade, especially if it is not kept perfectly dry and well protected from strong light. Where the material is to be kept in fluid media, such as alcohol, formalin, gelatin, glycerin, etc., it is impossible in most cases to preserve the natural colors except by resorting to special methods.

The method about to be described will not preserve the colors of flowers. It is effective only in cases where some shade of green is to be preserved, that is, where the distinctive color depends on the presence of chlorophyll in all or in certain cells. Usually it will also effectively preserve the browns, reddish browns, and yellows, such as occur in injured or diseased portions of stems, leaves, or fruits.

The principle involved is to bring about a combination of the chlorophyll in the cells of the plant with copper. The resulting compound, copper phyllocyanate,[1] is practically insoluble in any of the ordinary preserving media except strong alcohol, and is not destroyed by light. If the work be properly done the resulting green can scarcely be distinguished from the normal chlorophyll green. The amount of copper phyllocyanate in each cell will be proportionate to the quantity of chlorophyll which it contained, so that contrasts and shades due to this difference will be clearly brought out.

The most difficult part of the process is to get the copper into the

[1] Tschirch, A., Das Kupfer vom Standpunkte der gerichtlichen Chemie, Toxicologie, und Hygiene, pp. 27–55. 1893.

cells before the chlorophyll escapes or breaks down. In order to accomplish this, the air on the surface, and as far as possible in the intercellular spaces of the tissues to be treated, must either be removed by immersion in 90 to 95 per cent. alcohol for fifteen or twenty minutes, according to the size and penetrative resistance of the specimen, or else be freed by placing in water and removing the air with an air pump. Soaking for some time in boiled water after the latter has cooled is also effective. Good results may be obtained by combining all these methods. When the tissues are reasonably free from air the specimens should be placed in a dilute (5 per cent.) glycerol solution containing enough dissolved copper sulphate or copper acetate to give it a marked bluish tint. The solution should be boiled before using to free it from air. At the time of using, enough formalin should be added to make the solution about 1 per cent. The specimens should be left in this until all of the green parts have been penetrated by the copper and have assumed a bluish green color. They should then be removed to a dilute glycerin-formalin solution free from copper. This will gradually dissolve all the copper not in combination with chlorophyll and thus bring out the natural shades and variations. After thorough washing and clearing in this latter solution the material may be preserved, without change, in glycerin-formalin solution or any of the common media except strong alcohol.

For class use and exhibition purposes the specimens are best mounted in glycerin gelatin. Flat specimen jars with parallel sides and clear glass may be used, or in many cases better results may be obtained by mounting the specimens between glass plates of sufficient size. Old negative plates are good for this purpose. These are made into mounting chambers by cementing narrow strips of glass between the two sides and one end, the other end being left open. The most satisfactory cement found for this purpose is Canada balsam, boiled until when cool it will be hard but not brittle. Before the cell is made the glass should be thoroughly cleaned, as it is difficult to clean the inner walls afterwards.

When the cell is prepared the material is shoved in between the plates and arranged as desired. Two per cent. formalin is then added to the warm glycerin gelatin and this is poured in at one side to the bottom, from which it rises and surrounds the specimens. Any bubbles adhering to the specimens may be disengaged with a knitting needle or a fine, stiff wire, and the material finally arranged before the

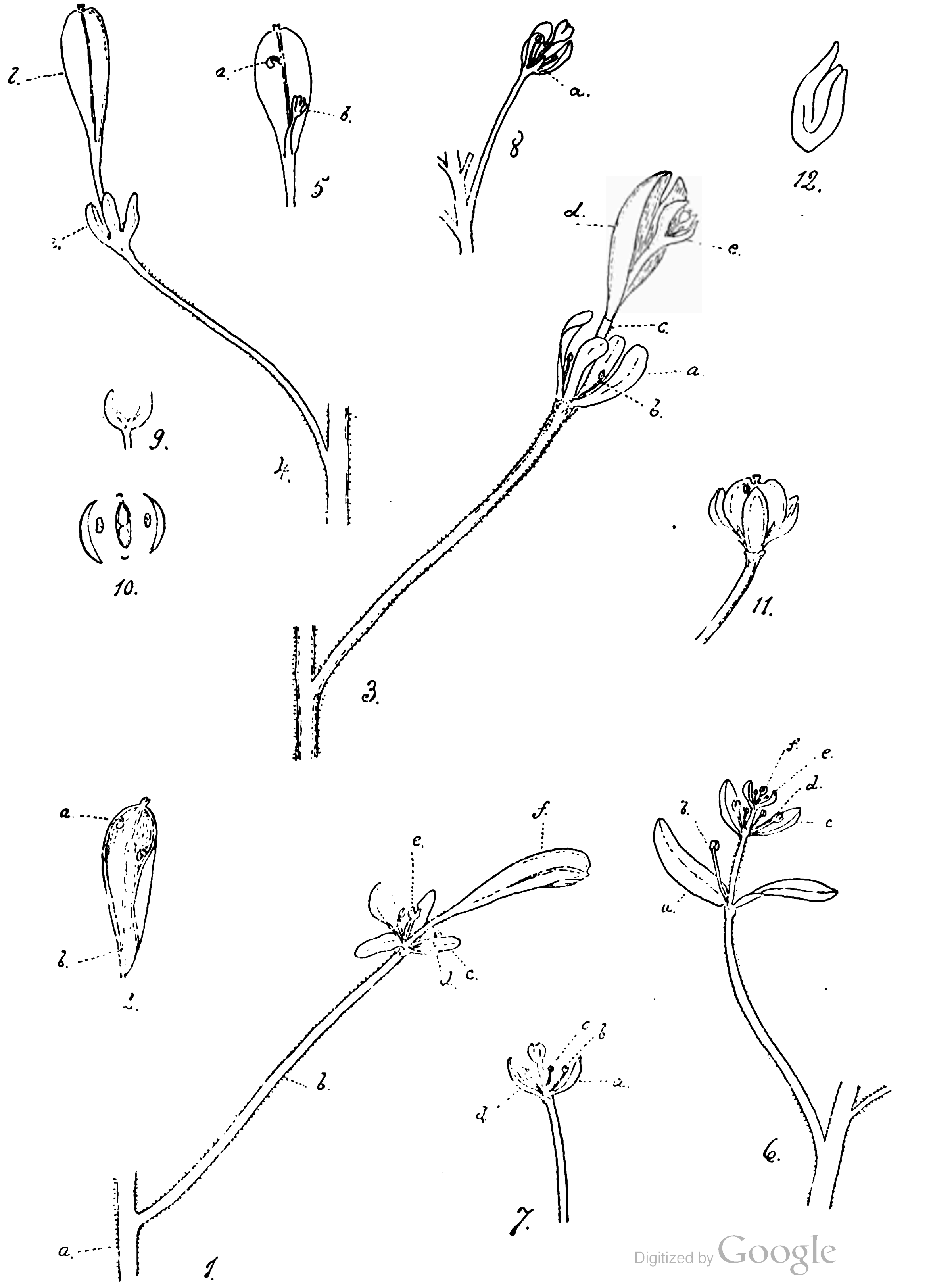
gelatin hardens. The plates should be sufficiently close so that the specimen will be held in place by friction against the glass while the gelatin is hardening. The amount of space required for different specimens is easily regulated by the thickness of the glass separating the plates. Modifications of this method can easily be made to meet the requirements of the material. The formalated gelatin hardens in a few hours, but it is best to allow the preparation to remain open at the top from twelve to twenty-four hours, filling in more gelatin if necessary. Finally, when the top has hardened and dried down about one-fourth of an inch, the space left should be carefully cleaned out and filled in with hot, hard balsam, which should make the seal perfectly air-tight. After this the mount should be cleaned, bound with lantern slide binders, and labeled.

The formula for the glycerin gelatin used is 20 parts of best quality French or other clear gelatin, 10 parts glycerin, and 100 parts water. Steam the mixture until the gelatin is melted, then cool down to 55° C., and add the white of one egg to about every 200^{cc}. After this is thoroughly incorporated steam again for about thirty minutes, or until the egg albumen is thoroughly cooked and white. Stir occasionally during this last steaming to insure complete coagulation of the egg. Now add malic or some similar acid to make the mixture neutral or slightly acid to litmus, and after carefully incorporating this strain while hot through cloth, and then filter through paper. In case it is desired to keep any of the glycerin gelatin in stock add, before filtering, one part salicylate of soda to each 100 parts of the mixture, or else keep the stock flask sterile by occasional steaming. I use the latter method.

As before mentioned, the formalin is not added to the stock gelatin, but to what is used in making each preparation at the time of filling or imbedding. When once the gelatin is hardened by formalin it is insoluble in water and cannot be melted even at boiling temperature. The formalin, of course, also makes it antiseptic. If the formalin is permitted to evaporate from the gelatin the latter may again become fluid.

Other formulas for glycerin gelatin may be used instead of the one described. Some prefer to use a larger quantity of glycerol and less water, which has an advantage, in that the mixture so prepared is less liable to dry out.

In conclusion the writer wishes to disclaim any originality in the



ROBINSON on LEPIDIUM APETALUM.

principles herein involved. The method is merely the application of well-known facts to economic ends.—ALBERT F. WOODS, *Division of Vegetable Physiology and Pathology, United States Department of Agriculture.*

A CASE OF ECBLASTESIS AND AXIAL PROLIFICATION IN LEPIDIUM APETALUM.

(WITH PLATE IX)

THE teratological specimen of Lepidium described below was collected by Mr. F. S. Collins at Malden, Mass., in August. Noting its remarkable character Mr. Collins has kindly referred it to the writer for examination. The plant is about 4^{dm} high, much branched, and already destitute of its lower leaves, so that it lacks some of the most characteristic features for specific identification. However, the cotyledons are distinctly incumbent, as shown in *fig. 12*, and the terminal racemes, which have normal fruit, show the orbicular pods and approximate regularly spreading pedicels characteristic of *L. apetalum* Willd., to which the plant is confidently referred. Most of the flowers show no sign of petals whatever, while in others there are rudimentary petals, as shown in *fig. 11*. These, however, have been found in normal specimens of *L. apetalum*, and therefore raise no appreciable doubt as to the identification. As mentioned above, the terminal racemes of the main axis and of several of the branches are entirely normal in their appearance. On the other hand, the numerous lateral racemes are all greatly modified. They are much looser, and the slender pedicels spread at various angles, instead of being regularly divaricate as in the normal racemes; but what is more conspicuous is the modification of the fruit from an orbicular pod to a long clavate or pear shaped body, which is not sessile in the calyx, but borne upon a filiform ascending stipe, in some cases nearly equaling the pedicels of the flowers.

The microscopic examination of one of these racemes shows a series of teratological modifications of the floral organs. Some of these changes are good examples of well recognized teratological phenomena, namely, ecblastesis and axial prolification, while others are too irregular for any very satisfactory classification or morphological interpretation. A cursory search in literature for records of similar monstrosities in the genus Lepidium has disclosed only a single mention of such

phenomena, namely, by Mr. Masters, who in his *Vegetable Teratology*, p. 148, gives Lepidium in a rather long list of genera, in which axillary prolification has been noted. However, this mention is accompanied by no details whatever, except that the prolification arose from the axils of the petals and stamens, while even the species is not stated upon which the observation had been made. The present case seems therefore worthy of record.

Unfortunately here, as in many cases of monstrosities, it is the mature plant and not its developmental stage which is known to us. Although it is possible to trace the varying malformations in the successive flowers of a given centripetal inflorescence, it is quite impossible to assume that the upper flowers represent the early stages through which the lower ones have passed, for often the modifications are very different in kind. However, in the absence of what might pass as developmental series, there is no better method open than to describe the successive flowers of a raceme, beginning at the lowest where the members are fully grown. The lowest flower in one of the teratological racemes is shown in *fig. 1*. From *a*, the axis of the raceme, the pedicel (*b*) diverges at a considerable angle and bears, at about the usual distance from the axis, the 4-membered calyx (*c*). Opposite the dorsal and ventral sepals are borne two stamens, each doubtless representing a pair of the longer stamens in the theoretical tetradynamous andrœcium. Of the lateral sepals one is empty, and the other bears in its axil a very rudimentary flower (*e*), which, itself scarcely larger than a stamen, is slender-pedicelled and possesses rudiments of three sepals, two stamens, and an ovary. This is, of course, a clear case of ecblastesis or budding from the axil of a floral member, for it is quite impossible to regard this little flower, with its clearly marked phyllome and caulome, as any modification of a stamen or petal.

From the center of the main flower, and quite continuous with its axis, springs what is evidently a stipitate elongated gynœcium (*f*) of somewhat irregular clavate form, bearing at the tip a small stigma, and showing upon the surfaces indication of the limits of the two carpels. *Fig. 2* represents the gynœcium with one valve removed. An ovule is borne upon each side, further demonstrating the gynœcial nature of the organ, and at the base of the capsule may be seen a very rudimentary flower, similar to the one borne in the axil of the sepal below, except that its diminutive calyx appears to have only two sepals instead of three. As this little flower is borne within and at the very base of

the gynœcium, it would seem to be a clear case of axial prolongation and prolification.

Fig. 3 represents a very similar case of prolification. Here, however, the main flower has four sepals and two stamens, without any sign of ecblastesis, while the gynœcium has undergone further development, the walls of the capsule being split down one suture, notched at the other, and thrown back as a sort of spathe-like envelope, from which emerges the here further developed axial prolification in the shape of a distinctly formed little trisepalous and diandrous flower (*e*). Its little ovary is borne upon a distinct stipe, which suggests the beginning of still further prolification. A careful examination has failed to reveal any traces of ovules or funiculi on the spathe-like organ (*d*). However, its analogy to the similar and ovuliferous structure shown in *fig. 1* is too close to leave any doubt as to its gynœcial nature. *Fig. 4* shows another flower higher in the raceme and of similar but less developed structure. The bases of two stamens were found within the calyx (*a*), and the interior of the gynœcium (*b*) is shown in *fig. 5* (where it has been divided through the middle of the valves). The placenta, which, from the way the ovary was divided, here appears as a median line, bears a single ovule, while at the base is a rudimentary flower similar to that shown in *fig. 2*.

A little higher upon the raceme occurred the proliferous flower shown in *fig. 6*. It has only two sepals, the dorsal and ventral (*a*), and one stamen (*b*) borne opposite the ventral sepal. The central axis was then prolonged and a second disepalous calyx (*c*) borne above. In the axils of each of these sepals were borne rudimentary flowers (*d*), and springing laterally from the axis at nearly the same height were three stamens. Only two of these can be shown in the figure, the third being concealed by the axis. The morphology of this flower is capable of various interpretations, and in its mature state the precise relation of the stamens to the sepals could not be satisfactorily made out; especially as the stamens were of an odd number. However, it seems likely that here the lateral sepals have been developed, and the dorso-ventral pair suppressed, while the longer pairs of stamens of the theoretical tetradynamous andrœcium are represented on one side by a single stamen, on the other by a pair. The structure of the minute flowers (*a*) was essentially as those described above, one of which is represented in *fig. 1, e*. The main axis was then produced by another distinct internode and bore another disepalous flower (*e*) which con-

tained two stamens, opposite the sepals (here doubtless the dorso-ventral pair), and in the middle a minute and obscure rudiment of still another flower (*f*). In the whole axis we have thus a case of triple prolification, together with distinct ecblastesis from each sepal of the middle pair.

The upper flowers of the raceme, which we have been following, although modified in various degrees, showed a greater and greater simplicity of structure, as will be seen from the three represented in *figs. 7, 8*, and *9*. The last shows the simplest form of flower observed. Its envelope consisted of two sepals with which alternated two obscure microscopic rudiments, doubtless the inner sepals. The androecium was formed of two stamens opposite the developed sepals, and the gynoecium of two carpels of normal position. *Fig. 10* shows a diagram of the flower. For the sake of comparison the normal flower from one of the terminal racemes of the same plant is shown in *fig. 11*. In this the minute rudiments of petals may be seen alternating with the sepals, and one of the two stamens is just visible protruding from behind the ventral sepal. The sessile normal capsule of orbicular contour of course presents a striking contrast to the deformed stipitate gynoecium of the modified flowers. The specimen shows an apparently sound and normal root and in general shows no cause for deformities described. The plant is preserved in the Herbarium of the Middlesex Institute at Malden, Mass.—B. L. ROBINSON, *Harvard University*.

EDITORIALS.

Cytology and Physiology

IT HAS SEEMED to the writer that two lines of botanical research, much cultivated at the present time, are in danger of sterility. The two lines referred to are the conventional cytology and physiology. The danger lies not in these great subjects, but in the narrow lines along which they are being cultivated. In the cytological field, by the use of various killing fluids and stains, investigators are obtaining various appearances. Aside from those well authenticated cell structures which have long been matters of common observation, these appearances are remarkably diverse, judging from the records of competent observers. Each investigator sees in his own facts a sequence of events, every step of which is necessarily an inference, no matter how reasonable it may seem to him. Enough has been observed to indicate that the maze of appearances that may be obtained from cell manipulation may not represent normal and constant phases of cell activity. It is certainly evident that the testimony obtained is ambiguous, for very numerous theories of cell operations may find support from observation, and in no field of investigation is it more true that one may find what he seeks. It is possible, therefore, that the mechanical cataloguing of these appearances may not be the most important direction of cytological investigation.

THERE IS NO THOUGHT to minify work that has been done, but rather to magnify the larger field that awaits cultivation. It seems reasonable to suppose that the fundamental principles of cell operations are comparatively few and simple. This would accord with all that has yet been discovered of fundamental principles. These same principles, however, may express themselves with a vast variety of detail, dependent upon conditions. Cytology is now concerning itself with this vast variety of detail, which of itself would seem to indicate that it is not fundamental, but dependent upon conditions. It would seem logical, therefore, with the details at hand, to direct investigation towards the conditions which determine these results. The

study of the effects of varying conditions upon the production of the various phases of cell activity would seem to be the fertile direction of cytology at present. Certain it is that through such investigations only will an approach be made to the fundamental principles. Such investigation has far more direct bearing upon the great problems of variation and heredity than any amount of examination of cell materials and of inference as to their relationships.

IN REFERENCE to the conventional physiology the same general statements are appropriate. Instead of attacking large problems, much of the work is advancing along purely mechanical lines in the record of isolated details. In other words, the outlying and endless details of expression of a few underlying principles are being catalogued, important enough in a way, but merely an incident in the progress of the real physiology. The fundamental problems are brought into view from the ecological standpoint. There is need of a renascence of physiology, for there has been a long period of sterility. The founders of modern plant physiology are being followed in the mechanical phases of their work rather than in their fructifying ideas.

CURRENT LITERATURE.

BOOK REVIEWS.

A new botany.

DR. WILLIAM A. SETCHELL, of the University of California, is another botanist to be added to the list of those who have attempted to meet the demand for a suitable text for secondary schools.[1] It goes without saying that Dr. Setchell's presentation of the subject is both scientific and complete, the only question being as to whether the text meets the requirements of the constituency for which it was prepared. It is true that some question might arise as to proportion of treatment when we find seven pages given to phyllotaxy and only two to the root, ten to the seed, and five to wind and insect-pollination, a fact which may perhaps be explained by the greater ease with which the favored topics may be fully treated in the school.

Turning to the main question we find in the preface (p. vii) "that this sketch is intended for beginners, either in the higher grades of the primary schools or in the secondary schools." An examination of the various chapters in the light of this statement awakens the suspicion that the author overshoots his audience, both in laboratory direction and definition. However skillfully approached by antecedent laboratory direction, the definition of a leaf (p. 25) as "an expanded, lateral structure of limited growth, borne on the stem and usually with a bud (or branch) in its axil" can stand to the average child of from twelve to fifteen years as little more than a form of words. The definition is a good working definition for the botanist, but is somewhat lacking as a working definition for the child. It is not a question of accuracy, merely one of adaptation. Concerning root hairs, we read (p. 18) "Examine the roots of the pea, bean, and corn, grown in loose, damp sawdust (or in a moist chamber), with a lens. Notice and sketch the root hairs. Upon what portions of the roots do they occur? Of what use are they to the plant?" This is the first mention made of root hairs, and indeed the only one save on p. 147, where reference is made to Kerner and Oliver for supplementary readings. No objection can be urged as to the content of the section quoted, but it is questionable whether as the result of such direction the average pupil in the "higher grades of the primary schools or in the

[1] SETCHELL, WILLIAM A.— Laboratory practice for beginners in botany. 12mo. pp. 198. New York and Chicago: The Macmillan Company. 1897. 90 cents.

secondary schools" will receive any clear cut conception of the position and function of root hairs. It is, again, merely a question of adaptation.

It is needless to multiply illustrations bearing upon the point under consideration. The book seems to be prepared for the teacher rather than the pupil. In the hands of a skillful teacher fairly versed in elementary botany it will be found of high value and exceedingly suggestive. In the hands of a teacher without previous laboratory experience its value would be greatly impaired, if not utterly destroyed. As an indication that the book was prepared for the teacher may be taken Appendix II, "Suggestions to the teacher," which covers 45 pages of the volume, the "laboratory practice" covering 129 pages. So large a proportion of space being deemed necessary for instructions to teachers furnishes at least indirect support to the view suggested above. It is a question as to whether pupils should be required to pay for suggestions to teachers, at least in such large measure.

After all, this is a criticism of a condition in our educational system rather than of Dr. Setchell's book. Conditions are so variant in the secondary schools of the country that the work possible for them, either as to content or extent, cannot yet be determined. The wide range of subjects taught, save in extremely exceptional cases, by every teacher in the secondary schools, precludes for the present, at least, the introduction of many of the methods of the specialist as well as many of his problems. The tendency is as mistaken as strong which is in the direction of the introduction of college and university methods into secondary schools. The chief objection to Dr. Setchell's book lies in the fact that it intensifies this tendency, that it fails to recognize the difference in conditions, indeed the difference in purpose which exists between secondary schools and universities.

The book will prove extremely helpful in elementary work in colleges and universities, and will find its way into the library of every teacher even though it does not entirely meet the needs of the secondary schools. Dr. Setchell is to be congratulated, not merely upon an honest attempt to solve a difficult problem, but also upon the production of a book which, both in form of presentation and content, is full of helpful suggestions.—S. C.

Cytological studies.

A notable volume[2] has recently come from the laboratory of Professor Strasburger. With certain important cytological problems to investigate, Professor Strasburger secured data from a wide range of forms by distribut-

[2] STRASBURGER (Eduard), OSTERHOUT (W. J. V.), MOTTIER (David M.), JUEL (H. O.), DEBSKI (Bronislaw), HARPER (R. A.), FAIRCHILD (D. G.), SWINGLE (Walter T.).—Cytologische Studien aus dem Bonner botanischen Institut. Separatabdruck aus den Jahrbüchern für wissen. Bot. 30: 1–268, *pl. 18*. 1897. [Heft 2 u. 3]. Berlin: Gebrüder Borntraeger. *M* 27.50.

ing the work among seven of his research students. This method of securing large results from some single problem, rather than small results from scattered problems, commends itself to every laboratory in which a group of research students may be working. We are pleased to note that of the seven collaborators five are American students.

Osterhout investigated the spore mother cells of *Equisetum limosum*, with especial reference to the question of the existence of centrosomes and their participation in the process of spindle formation. He gives perhaps the most complete series of stages in the development of the spindle that has yet been worked out in a vascular plant. The sequence of events is briefly as follows: kinoplasmic fibers form (1) a felted layer around the nucleus; (2) they are radially placed; (3) the fibers gather in bundles; (4) the nuclear membrane disappears and the fibers come in connection with the linin network and the chromosomes; (5) the fiber bundles are arranged in two groups to form finally a bipolar spindle. Centrosomes are not found and could play no part in the process as described. The author also figures characteristic tetrad chromosomes.

Mottier has made further studies on the pollen mother cells of a number of lilies and dicotyledons, chiefly with reference to spindle development and chromosome reduction. As to the method of spindle formation, his results are in substantial agreement with those of Osterhout. He finds in lilies no such governing centers in mitosis as were described by Guignard. He shows also that the chromosomes in heterotypic division pass through essentially the same stages in the plants studied as have been described by later authors for animal nuclei, and argues strongly for the view that the numerical reduction of the chromosomes before the heterotypic division is only a pseudo-reduction, and that a qualitative division in Weismann's sense occurs in the second division. We must note that a later joint paper by Strasburger and Mottier[3] revises this conclusion, and returns to the doctrine that every mitosis is accompanied by a longitudinal splitting of the chromosomes.

The formation of small supernumerary pollen grains in the pollen tetrads of Hemerocallis was studied by Juel. He finds, as Strasburger has described, that these grains in every case owe their origin to the isolation of individual chromosomes either before or after splitting in the equatorial plate. Such single chromosomes form nuclei which function as normal nuclei in every respect. If isolated in the first division the small nucleus forms a spindle and divides, just as its normal sister nuclei. It is difficult to see how centrosomes could be present for these micro-spindles. Juel also confirms, for Hemerocallis, the method of spindle development described by Osterhout and Mottier.

Debski finds in Chara a type of spindle and cell plate formation which

[3] Über den zweiten Theilungschritt in Pollenmutterzellen. Ber. d. deutsch. Bot. Ges. Heft 6. 1897.

resembles much more closely the process in vascular plants than in the algæ to which Chara has been assumed to be more closely allied. The stages agree in general with those described by Osterhout. No functional centrosomes are to be found. "Extra nuclear nucleoles" are abundant, and seem to furnish material for the spindle fibers and cell plate. The structures assumed by Kaiser to be centrosomes are doubtless such nucleolar masses.

In contrast to the method of spindle development described for the vascular plants and Chara, Harper finds in the ascus of Erysiphe a type much more nearly resembling that described for animal cells by Hermann and Flemming. A disk shaped central body is present with each nucleus throughout nuclear division and spore formation in the ascus. At the beginning of spindle building this body is surrounded by a system of radiating kinoplasmic fibers. Then two such centers appear beside the nucleus and separate gradually to form the poles of the spindle. From these centers fibers extend and are attached to the chromosomes. In the bounding off of the ascospores by free cell formation the polar radiations of the last preceding mitosis perform an entirely new function. They grow in length and swing back around the nucleus, which has been drawn out into a beak beneath the central body, and fuse laterally to form a new plasma membrane around the young spore. The bounding layer of the young ascospore is thus composed of the same kinoplasmic substance as the polar radiations and spindle fibers. The spore wall is formed much later.

In Basidiobolus Fairchild finds very characteristic barrel shaped multipolar spindles. The fibers converge in groups, and each group ends in a strongly staining body. These bodies, taken together, make up a sort of polar plate. Here also a typical cell plate is probably formed as in Chara. Fairchild further notes the very interesting fact that in Basidiobolus we have one of the shortest possible life histories, involving at the same time an alternation of sexual and asexual fruit forms. Two successive nuclear divisions may complete the entire round of conidium and zygospore formation.

Swingle has given for Stypocaulon the most complete description of a sharply differentiated centrosome, and its division and migration during spindle development, which has yet been worked out in plant cells. The process here, also, is much the same as in animal cells. The apical cell of this plant is almost constantly in division, and the polar radiations and centrosomes persist in it through the resting stages of the nucleus. The spindle has both "mantle" and "central" fibers, and at the time of its greatest development the polar radiations are much reduced. The amount of kinoplasm at the two poles is regularly unequal. The contrast in structure and reaction of the fibrous kinoplasm and alveolar trophoplasm is nowhere more sharply shown than in this apical cell of Stypocaulon. Cell division takes place without the aid of connecting "fibers" or constriction of the plasma

mass. A cell plate is formed in the trophoplasm and is split into two new plasma membranes before the building of the new cellulose wall.

Strasburger finds that the oogonium nucleus of Fucus shows the reduced number of chromosomes in its first division after the stalk cell has been cut off. Centrosomes in the Fucus cell are sharply differentiated, and the spindle is formed much as in Stypocaulon. In cell division in the oogonium the cell-plate appears first as a layer of granules, each of which divides, and the so formed elements fuse to form the bounding membranes of the daughter cells. Fusion of the male and female pronuclei and the first division of the fertilized egg nucleus are also described. Centrosomes in connection with these pronuclei were not observed, but the presence of such a body with the antherozoid nucleus is regarded by Strasburger as not improbable. He also gives a résumé of the results presented in the different papers, and a more theoretical discussion of their bearing on doctrines of cell structure and reproduction.

While zoologists are inclining to the conclusion that the archiplasm of Bovéri is only a structurally modified portion of the common cytoplasmic mass, the evidence in all the above studies goes to show that there are two substances, kinoplasm and trophoplasm, in the cytoplasm of the plant cell, distinct both in structure and chemical composition, and readily distinguishable by their visible structure and staining properties. To the kinoplasm falls the active work of mitosis, in many cases of cell division. In the ascus it covers the entire surface of the young spore, which suggests that the *Hautschicht* may be also kinoplasmic.

We must conclude, so far as existing evidence is concerned, that there are two widely distinct types of spindle formation, the one occurring in animals and many of the lower plants, the other in the higher vascular plants. In the first the forces of mitosis act in centered systems, while in the other the kinoplasmic fibers singly or in bundles are the acting units.

The work of Mottier and Osterhout serves to emphasize greatly the similarity between the chromosome figures in animal and plant cells in the so-called heterotypic mitosis. The interpretation of these figures, however, remains still in doubt.

The whole series of studies is of great importance, and a review can do it but scant justice. The conclusions reached demand such a readjustment of former ideas that real criticism must await further investigation. Any theory, however, which differentiates the higher from the lower plants in these fundamental cell processes seems likely to have an uncertain tenure, especially as it associates the lower plants with animals. The tendency of investigation has been to establish similarity rather than diversity in all fundamental life phenomena. This objection is purely theoretical, of course, but it is so firmly intrenched in the minds of biologists that the proof to the contrary will

have to be very strong. We cannot help but feel that while the observations recorded in these "studies" are of great interest, some of the conclusions are entirely too sweeping. The occurrence of centrosomes in the higher plants is far from settled, and the occurrence of a multipolar phase as necessarily antecedent to the bipolar phase of a spindle may be regarded as still an open question.

The result of these "studies" will be to stimulate investigation greatly rather than to command immediate belief in the more important conclusions, and investigation is always more important than belief.—J. M. C.

MINOR NOTICES.

T. D. A. COCKERELL[4] has published a remarkably full list of the food plants of scale insects. The preparation of the summary has emphasized two facts, viz., "the unexpected number of coccids found on many of the cultivated trees and shrubs, and the frequency with which species dangerous to fruit trees will occur on ornamental plants, which may be carried from place to place and be the means of disseminating the scales."—J. M. C.

THE FOURTH PART of *Flora Franciscana*[5] has just appeared, and is devoted to the Compositæ. As Professor Greene has been much concerned with various sections of this great group, it is of great interest to have the results of his studies brought together, so far as they can be within the limited range of this work. Space forbids mention of the numerous shiftings of generic boundaries and the new species described. Many of the author's views of the genera of Compositæ have been published already, but the contribution before us contains much new material. The richness of the Californian flora may be judged by the fact that the portion of it represented in this *Flora* contains 113 genera of Compositæ, and 492 species. The general character of the composite flora may be judged from the following summary of the number of species under each of the ten groups called "sub-orders," and named as follows: Eupatoriaceæ 9, Asteraceæ 149, Gnaphaliaceæ 30, Ambrosiaceæ 7, Helianthaceæ 29, Madiaceæ 79, Helenioideæ 76, Anthemideæ 25, Senecionideæ 59, Cynarocephalæ 29.—J. M. C.

NOTES FOR STUDENTS.

ITEMS OF TAXONOMIC INTEREST are as follows: Karl M. Wiegand[6] has been studying *Galium trifidum* and its North American allies, and finds that this reputed "variable species" is a plexus of forms. He has used the form

[4] Proc. U. S. Nat. Mus. **19**: 725-785. 1897.

[5] GREENE, EDWARD L.—Flora Franciscana. An attempt to classify and describe the vascular plants of middle California. Part IV. Pp. 353-480. San Francisco: Payot, Upham & Co. London: William Wesley & Son. 1897. $1.00

[6] Bull. Torr. Bot. Club **24**: 389-403. 1897.

of the seed in cross-section as an important diagnostic character, and has been able to separate forms heretofore thrown together. The original *G. trifidum* L. seems to be Gray's var. *pusillum*, and other forms which have been loosely associated with it are here set apart as *G. arcuatum*, n. sp., *G. tinctorium* L. with three new varieties, two new varieties of *G. trifidum*, *G. cymosum*, n. sp., and *G. palustre* L. Charles L. Pollard[7] has described two new violets, *V. Porteriana* from Pennsylvania, and *V. flavovirens* from Idaho. The same author[8] also establishes *Oxytria* Raf. as the oldest generic name for the three species commonly described under Schoenolirion. Gust. O. A.: N. Malme has recently contributed to our knowledge of South American plants by the publication of three papers based upon his own collections. The first treats of the Xyridaceæ,[9] including descriptions of four new species of Xyris and one of Abolboda. The second treats of the genus Burmannia[10] two new species being described. The third discusses the Polygalaceæ.[11]

In all of them it is important to note that the groups are presented in their biological aspects.—J. M. C.

MISS ETHEL SARGANT'S second paper[12] on the formation of sexual nuclei in *Lilium Martagon* treats of spermatogenesis. It will be remembered that in the first paper on oogenesis the conclusion was reached that in no one of the three nuclear divisions which immediately precede the formation of the ovum is there a transverse fission of the chromosomes. Dr. Haecker's hypothesis demands that in one of these three divisions there must be a transverse fission of chromosomes, and also a transverse fission in one of the four divisions which lead to the formation of the male pronucleus.

The nuclei of the pollen mother cells pass through a period of development which corresponds in every detail to that of the macrospore nucleus. The amorphous chromatin which was described in the first paper appears again in the pollen mother cells. The synapsis stage is discussed at some length, and the conclusion is reached that synapsis is a normal phenomenon and not an artefact due to reagents. The conclusion is based mainly upon a study of living material. Three features characterize synapsis: "a more or less complete disappearance of the nuclear membrane, partial solution ot the nucleolus, and contraction of the chromatin thread." In late synapsis the nuclear membrane begins to reappear, nucleoli are reconstructed from an amorphous nucleolar mass, the chromatin threads become looser, and the

[7] Op. cit. **24**: 404–405. 1897.

[8] Op. cit. **24**: 405–407. 1897.

[9] Bihang till Kongl. Svenska Vet.-Akad. Handl. **22**: [no. 2]. 1896.

[10] Op. cit. **22**: [no. 8]. 1896.

[11] Öfversigt af Kongl. Vet.-Akad. Förhandl. no. 4. 1897.

[12] The formation of the sexual nuclei in *Lilium Martagon*: II Spermatogenesis. Ann. Bot. **11**: 187–224. 1897.

familiar spirem stage is reached. The nucleus is smaller than the embryo sac nucleus of the same stage, but the ribbons have about the same width in both. "It seems probable that the linin matrix of the ribbon is formed in great part from the substance of the half dissolved nucleolus." The double row of chromatin granules is first demonstrated with certainty during the ynapsis stage, but Miss Sargant believes that it occurs earlier. As in the embryo sac nucleus, longitudinal splitting of the spirem ribbon precedes the division into the segments which constitute the chromosomes. Each of these chromosomes thus consists of two distinct longitudinal segments which separate during karyokinesis. Each of these segments shows a double row of chromatin granules, thus suggesting a fourfold character of the chromosome and recalling the tetrad of the animal spermatocyte, which in Ascaris results rom a double longitudinal fission. A second fission could not be demonstrated either in the embryo sac or pollen mother cell of Lilium. Spindle fibers appear from two or three points in the cytoplasm, forming a spindle which is rarely symmetrical at first. Attached to each chromosome are two bundles of fibers which seem to pull the chromosomes toward the poles. The daughter chromosomes in the diaster stage are commonly V-shaped.

The number of chromosomes was twelve in all cases in which they could be counted with certainty. There is a suggestion that the daughter chromosomes of the first division retain their identity within the daughter nucleus.

The nucleus of the pollen grain divides once before the grain is shed, and he daughter chromosomes separate exactly as in the vegetative nucleus. No centrosomes were observed, but there was often a differentiated mass of cytoplasm from which radiations could be traced into the surrounding cytoplasm. The generative nucleus, which divides soon after the formation of the pollen tube, shows a definite longitudinal splitting of the chromosomes. The generative nuclei are exactly alike and neither possesses a nuclear membrane or a nucleolus. In the three later divisions the number of chromosomes could not be counted with certainty, but there were about twelve.

In both spermatogenesis and oogensis the parent chromosome gives rise to daughter chromosomes by longitudinal fission. The seven divisions of these series are all distinguished by having twelve chromosomes instead of twenty-four. Of these seven divisions the first of each series differs decidedly from the rest, which are distinguished from the vegetative type only by the reduced number of chromosomes. The name "homotype," already in use by zoologists, has been given to the five divisions which follow the vegetative ype, while the term "heterotype" is applied to the first division in each series. In the spirem stage of the homotype division the ribbon stains uniformly, while in the corresponding stage of the heterotype the ribbon is bordered by a double row of cyanophilous granules. In the homotype division the chromosomes are formed of lengths of the spirem ribbon, the

longitudinal fission of the chromosomes appearing later, while in the hetero-type longitudinal fission of the whole ribbon precedes the segmentation into chromosomes. Segments of homotype chromosomes appear homogeneous during karyokinesis, while those of the heterotype show a row of granules on each margin. The segments of homotype chromosomes are nearly parallel and quite regular, while those of the heterotype are twisted and contorted in the nuclear plate. Segments of the homotype diaster are usually hooked, while those of the heterotype diaster are V-shaped.—C. J. C.

NEWS.

Mr. J. G. Jack will conduct a series of lectures and field meetings at the Arnold Arboretum during the autumn, for the purpose of supplying popular instruction about the trees and shrubs which grow in New England.

There has just been organized the "Louisiana Society of Naturalists." It is incorporated, and starts out with nearly forty-five members, nearly all of whom are workers in some branch of natural science. The secretary is Mr. E. Foster, of New Orleans.

Mr. W. L. Bray, who has just returned from work at the University of Berlin, has accepted a position in the University of Texas in charge of the botanical work. As his recent studies have been along ecological lines, the flora of Texas will receive his chief attention.

The current number (September) of *Popular Science Monthly* contains an account of "The giant cactus," by Professor J. W. Toumey, and a paper upon "The scope of botany," by Professor George J. Peirce.

The illustrious Danish naturalist Japetus Steenstrup died at his home in Copenhagen on June 20, 1897, at the advanced age of 84 years. Although his most prominent works were purely zoological, he also contributed largely to the progress of botanical science. Besides being one of the editors of *Flora Danica*, he made extensive studies of the subfossil fauna and flora of the Danish peat-bogs, the result of which enabled him to demonstrate the prehistoric nature and culture in Denmark. His lectures in natural history and his warm interest for his pupils have made him one of the most popular and most admired of Danish naturalists.—Theo. Holm.

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BOTANICAL GAZETTE

OCTOBER 1897

NOTES ON THE FECUNDATION OF ZAMIA AND THE POLLEN TUBE APPARATUS OF GINKGO.

HERBERT J. WEBBER.

(WITH PLATE X)

A PRELIMINARY discussion of the development of the pollen tube apparatus[1] and the antherozoids[2] of Zamia was given by the writer in the June and July numbers of this journal. The object of the present preliminary paper is to call attention to some of the peculiar phenomena which occur during the process of fecundation in Zamia, and to certain features in the development of the pollen tube apparatus of Ginkgo, in which further light is thrown on the origin of the centrosome-like body occurring here as in Zamia.

For a considerable time during the development of the pollen tube apparatus in Zamia the archegonium remains in nearly the same stage of development, simply increasing gradually in size. During this period the very large nucleus remains at the apex of the archegonium as figured by Treub in *Cycas circinalis*.[3] Shortly before fecundation this nucleus divides, and

[1] Peculiar structures occurring in the pollen tube of Zamia. BOT. GAZ. 23:453. June 1897.

[2] The development of the antherozoids of Zamia. BOT. GAZ. 24:16. July 1897.

[3] Recherches sur les Cycadées. Ann. du Jardin Bot. de Buitenzorg 4: *pl. 1. fig. 8.*

a small cell is cut off at the apex of the archegonium, which corresponds to the canal cell of the conifers. Until the publication of Ikeno's preliminary note announcing the discovery of this canal cell in *Cycas revoluta*[4] it had been supposed that it was not formed in the Cycadaceæ. It would seem, however, from its occurrence in Cycas and Zamia that it is commonly formed in the Cycadaceæ as in the Coniferæ. Hirase has also recently described the formation of this cell in *Ginkgo biloba*. I have not observed the division of the nucleus leading to the formation of the canal cell in Zamia, but the process probably corresponds very closely to that occurring in Cycas and Ginkgo. Before fecundation the canal cell appears to break up and lose its identity, as only occasional traces of it can be found at that time.

After the division which leads to the formation of the canal cell, the lower nucleus, which forms the oosphere, travels downward and takes a position somewhat below the middle of the archegonium. It is usually spherical or slightly elliptical, and its contents are much less dense than the surrounding cytoplasm of the archegonium with which it forms a marked contrast. The mature archegonium is usually elliptical or slightly reniform and is about 3^{mm} in length and 1 to 1.5^{mm} in width. As explained in my previous papers, several antherozoids commonly enter each archegonium, two being usually found and sometimes three or four. The entire antherozoid enters unchanged, swimming in between the ruptured neck cells. Only one of the antherozoids is concerned in fecundation, and the others are usually found between the protoplasm and wall of the archegonium, presenting their original form and appearance, or in some stage of disintegration. Occasionally one of the antherozoids not concerned in fecundation pushes for a short distance into the contents of the archegonium, but it apparently does not mingle with the protoplasm of the archegonium, as it is always found in such cases to form a distinct body which stains very differ-

[4] Note préliminaire sur la formation de la cellule de canal chez le Cycas revoluta. The Botanical Magazine 10:61. September 1896.

ently. The antherozoid which is utilized in fecundation swims into the protoplasm of the archegonium for a short distance, where it undergoes a remarkable change. In very numerous sections shortly after fecundation the spiral ciliiferous band of the antherozoid which, it will be remembered, is developed by the gradual extension of the membrane of the centrosome-like body, appears uniformly lying in the protoplasm at the apex of the archegonium. It shows very plainly and presents nearly the original form of the antherozoid (*fig. 3*), but all traces of the nucleus and cytoplasm, which originally made up the main body of the antherozoid, have disappeared. The band, preserving its original spiral form, now lies free in the protoplasm of the archegonium. No instance has been found of the occurrence of more than one antherozoid presenting this appearance, and in every fecundated archegonium carefully examined one of these bands has been found. Since it was evident from this that the nucleus of this antherozoid must be the one utilized in fecundation, search was made for intermediate stages. Fortunately several have been found which support this view of the matter. In three different cases, immediately in the rear of the isolated spiral ciliiferous band described above, a nucleus has been found which, judging from its size and appearance, is evidently the nucleus of this antherozoid (*figs. 1* and *2*). I have been unable to determine the fate of the cytoplasm which surrounded the nucleus in the original antherozoid form, but from the slightly different density and constitution of the protoplasm which now lies between the spirals of the ciliferous band, it would seem that it simply unites with that of the archegonium. I have thus far been unable to find any other intermediate stages in the passage of the male nucleus, but it may be assumed from the above observations that shortly after the antherozoid enters the protoplasm of the archegonium, the nucleus escapes from the body of the antherozoid and from this point wanders alone to the oosphere. After fecundation the male nucleus appears as a small nearly round body in the upper portion of the oosphere into which it has penetrated (*fig. 3*).

The contents of the male nucleus is at this time much more dense than that of the oosphere.

The isolated ciliiferous band lying free in the protoplasm at the apex of the archegonium evidently retains its identity for a considerable time. It has been observed in several archegonia after the formation of many free nuclei by the repeated divisions of the oosphere. Frequently the spindles of some of these free nuclei in division have been observed between its spirals. The band ultimately disappears, its substance probably being consumed by the forming embryo. The primary function of the ciliiferous band thus certainly ends with the transporting of the male nucleus from the pollen tube to the archegonium. The exceptional size of the antherozoids of Zamia permits these features to be seen very plainly, while in the various plants in which the entrance of the antherozoids has been studied, they are so small that thus far the fate of the cilia and cytoplasm, which are not generally supposed to be concerned in fecundation, has not been determined with certainty. Professor Strasburger,[5] in his recent study of the fecundation of Fucus, concludes, mostly from comparative size, that shortly after the entrance of the antherozoid its cytoplasm unites with that of the egg cell, and only the nucleus continues its passage and unites with the egg nucleus. My observations clearly indicate that this is the case also in Zamia.

A special examination has been made of the divisions of the oosphere immediately after fecundation for the occurrence of a centrosome which, if present, would be suggestive in connection with the centrosome-like body of the antherozoid. Thus far, however, I have been unable to find any indication of such an organ. Careful examinations have been made of dividing nuclei in many stages of development from the second division of the oosphere until the embryo is fairly well formed. The first division of the oosphere has not been observed. In many cases the kinoplasm may be found presenting somewhat the appearance

[5] Kerntheilung und Befruchtung bei Fucus. Jahrbücher f. wissenschaft. Bot. 30:363. 1897.

of an aster, but in no case has any body been noticed which could be considered a centrosome. Hirase, in his studies of Ginkgo, states that he was unable to find any indication of a centrosome either in the first or the later divisions of the oosphere.[6] It should be remembered in this connection that Overton[7] states that in Ceratozamia the pollen mother cells and endosperm shortly after the formation of the free cells in the embryo sac are very favorable objects for the study of the centrosome. It would seem, however, from Hirase's studies on Ginkgo, my own on Zamia, and the recent cytological studies at the Bonn Botanical Institute, that Overton may possibly have been mistaken.

In the generative cell of *Ginkgo biloba*, according to Hirase,[8] two "attractive spheres" occur which are visible without staining. These organs are unquestionably the same as the centrosome-like bodies which I have described in Zamia. Hoping thus to obtain further information as to the nature and origin of these bodies, I have made a study of the early stages of the development of the pollen tube of Ginkgo. In developing fruits collected June 12, the pollen was found to have germinated and formed a tube about as long as the diameter of the pollen grain. In this stage (*fig. 4*) the vegetative nucleus in all cases examined had already wandered into the tube and was commonly found near its distal end. The stalk cell and generative cell, which, as Strasburger has shown, are formed in the pollen grain before pollination, had at this period increased only slightly in size, and were yet much smaller than the vegetative nucleus. The generative cell in this stage is crescent shaped and projects into the center of the pollen grain. The nucleus is about 5.6μ in diameter and occupies about one-half of the cell. The nucleus of the stalk cell is somewhat smaller, while the vegetative nucleus is much larger, being about 10.5μ in diameter.

[6] Études sur la fécondation et l'embryogénie du *Gingko biloba*. Journ. of the Col. of Sci. Imp. Univ. Japan **8** : 307.

[7] Ueber die Reduction der Chromosomen in den Kernen der Pflanzen. Viertel jahrschr. d. naturforsch. Ges. in Zürich **38** : 178.

[8] Notes on attraction spheres in the pollen cells of *Ginkgo biloba*. The Botanical Magazine **8** : 359.

During June and the early part of July the pollen tube continues gradually to grow in diameter, increasing but slightly in length, until by the middle of July it has reached a diameter somewhat greater than the pollen grain, which at this time forms simply a cap over the proximal end of the tube (*fig. 5*). The generative and stalk cells have increased greatly in size and have pushed out of the pollen grain into the tube, but still remain attached. A careful search was made in the generative cells of material collected at various periods up to this time for the centrosome-like bodies or "attractive spheres" described by Hirase, but in no case was any indication of them discovered. In material collected July 20, however, the centrosome-like bodies were found for the first time (*figs. 5* and *6*). There is considerable variation in the rapidity of development of different pollen tubes in fruits collected the same day, and it was only in the most advanced tubes that the centrosome-like bodies could be found at this time. In material collected July 27 they were found in almost every generative cell examined. Two of the spheres occur uniformly in each generative cell and are located in the cytoplasm on opposite sides of the nucleus about midway between the nuclear membrane and the cell wall (*fig. 6*). They are spherical and of uniform size, but are quite small, being only about 0.6 to 0.7μ in diameter. They are very plainly distinguishable, however, as they stain differently from the surround ing cytoplasm. The radiations of kinoplasm are at this time few in number and comparatively short. They are thick at the base where they join the so-called centrosome-like bodies and are reduced to a very fine point at the end. The generative cell in this stage is usually nearly spherical, being somewhat compressed on the side attached to the stalk cell. It varies in size, being commonly from 25 to 35μ in diameter. The nucleus is spherical, from 16 to 18μ in diameter, and contains a nucleolus. Both the nucleolus and the centrosome-like body are stained bright red with saffranin in using the Flemming triple stain, as in the case of the centrosome-like body and nucleolus of Zamia.

During August the stalk cell and generative cell continue

to increase gradually in size. In material collected August 30 the generative cell was found to have become elliptical in shape, its dimensions being now about 45 by 65μ (*fig. 7*). The nucleus, on the contrary, had become compressed and was now fusiform instead of spherical, its major axis being at right angles to the major axis of the cell. It was commonly about 45μ in length and 18μ in width. The centrosome-like bodies had increased in size, being now from 2 to 2.5μ in diameter. The radiating filaments of kinoplasm were still few and short as in the preceding stage. Between the centrosome-like body and the nuclear membrane on each side of the nucleus a regular spherical body of nearly uniform size, 7 to 8μ in diameter, had made its appearance. It stained bright red with saffranin, the same as the nucleolus and centrosome-like body, but not quite so intensely. The nature and function of these nucleolus-like bodies are still in doubt. That they are not caused by the action of fixatives is quite clear, as Hirase[9] observed them in living unstained generative cells. Furthermore, I find them uniformly in generative cells at this stage, while in a slightly younger stage they do not occur. Zimmermann[10] being unable to account for these bodies suggested that what Hirase supposed to be the nucleus was in reality the generative cell, and that these two nucleolus-like bodies were to be considered as vegetative nuclei. He was, however, mistaken in this interpretation, as will be apparent from an examination of my *figs. 5* and *7*. In several instances spherical masses of similar material have been observed in other locations in the cell. These were smaller and their presence did not apparently affect the size of the main masses situated between the centrosome-like bodies and the nucleus, which were also present in the same cell. The reactions of these bodies to stains would indicate that they may be masses of extra-nuclear nuclein.

The results of my studies on Zamia and Ginkgo are now

[9] On the attraction spheres in the pollen cells of *Ginkgo biloba*. *Ibid.* p. 360; also Études sur la fécondation et l'embryogénie du *Ginkgo biloba*. *Ibid.* p. 318.

[10] Die Morphologie und Physiologie des pflanzlichen Zellkernes 107.

sufficiently complete to enable one to judge quite accurately as to the real nature of the centrosome-like body which occurs in the generative cells of these plants. In Ginkgo the centrosome-like body cannot be detected in the generative cell until two months after the germination of the pollen grain, when the generative cell has greatly increased in size. It then appears as a very small round body in the cytoplasm between the nuclear membrane and the cell wall. It gradually increases in size, and a month later is found to have grown to three or four times its original diameter. It is thus evident that in Ginkgo these bodies originate in the cytoplasm of the generative cell. The early stages of development of the generative cell of Zamia have not been studied, and, therefore, in this case their first appearance has not been observed. It has, however, been determined that they increase in size here as in Ginkgo. In Zamia the centrosome-like body, as described in my previous papers, finally ruptures during the division of the generative cell, and the membrane formed by its wall becomes greatly extended in length, ultimately forming a narrow band arranged in the form of a helicoid spiral on one side of the cell. This band gives rise to the cilia which form the motile organs of the antherozoid. In fecundation, as shown above, this ciliiferous band developed from the centrosome-like body is left in the cytoplasm at the apex of the archegonium, while the nucleus wanders alone from that point to the oosphere. The ciliiferous band surely remains intact at the apex of the archegonium for some considerable time after fecundation, and is then gradually absorbed as the embryo develops. In the divisions of the oosphere immediately following fecundation, furthermore, no indication of any body resembling a centrosome could be found. Hirase, who studied the division of the oosphere of Ginkgo, was also unable to find any trace of a centrosome. It thus seems quite evident from the above facts that the bodies in question cannot be considered as true centrosomes. The mere fact that during a part of their existence they are situated approximately where a centrosome might be expected to occur if present, and for a considerable time during the resting condi-

tion of the nucleus have the kinoplasmic filaments centered upon them, is not sufficient reason for considering them to be centrosomes, when they differ in many other important features. Their origin, function, and fate are totally different from that of any organ known to the writer which has been considered to be a centrosome. If the bodies in question are compared to typical centrosomes such as occur in Fucus, as described by Strasburger,[11] and in Stypocaulon as described by Swingle,[12] the dissimilarity of the two organs becomes striking. The two most important features of a centrosome, namely, continuity from cell to cell, and forming the center of an aster at the pole of the spindle during karyokinesis are not shown by the centrosome-like bodies of Zamia and Ginkgo. In view of our more complete knowledge of the origin, function and fate of the centrosome-like bodies in the two plants under consideration it is evident that they must be considered distinct organs of the protoplasm of spermatic cells, having for their primary function the formation of the motile cilia of the antherozoids. I am not aware that any distinguishing name has been applied to such an organ, and I would here suggest the name *blepharoplast*[13] to distinguish them from other organs of the cell.

In two exceedingly important preliminary papers recently presented before the German Botanical Society, Belajeff has described the occurrence of an organ in the spermatic cells of *Filicineæ*[14] and *Equisetineæ*[15], which is doubtless identical with the blepharoplasts of Zamia and Ginkgo. They apparently originate in the spermatic cells, since no trace of them could be discovered in the spermatic mother cell in the resting condition or during karyokinesis. The first changes visible in the metamor-

[11] Kerntheilung und Befruchtung bei Fucus. Jahrbücher f. wissenschaftl. Bot. **30**: 369. 1897.

[12] Zur Kenntniss der Kern- und Zelltheilung bei den Sphacelariaceen. Jahrbücher f. wissenschaftl. Bot. **30**: 326. 1897.

[13] From βλεφαρις, *eyelash* or *cilium*; and πλαστος, *formed.*

[14] Ueber den Nebenkern in spermatogenen Zellen und die Spermatogenese bei den Farnkraütern. Berichte d. deutsch. bot. Ges. **15**: 337. July 1897.

[15] Ueber die Spermatogenese bei den Schachtelhalmen. Berichte d. deutsch. bot. Ges. **15**: 339. July 1897.

phosis of the spermatic cells occur in these organs. They gradually become extended into a thread which assumes the form of a helicoid spiral of which the extended turns of the posterior end surround the nucleus. The cilia of the antherozoids are developed from the anterior end of this spiral, appearing first as small protuberances on the thread, which finally become greatly extended and form the cilia. It is remarkable that in the comparatively very small spermatic cells of the Filicineæ and Equisetineæ Belajeff should have been able to trace so accurately the method of formation of the ciliiferous band and cilia. The process which he describes as occurring in these plants is identical in all essential features with that which I have described in Zamia, and its publication was almost simultaneous with that of my article.

From previous observations on the spermatogenesis of Characeæ Belajeff is inclined to think that the same organ occurs there also.[16] He further calls attention to the occurrence of somewhat similar organs in the spermatic cells of certain animals.

Belajeff's studies greatly strengthen the view that the blepharoplasts are distinct organs of the cell, differing from centrosomes, and strongly indicates that they occur very generally in the spermatic cells of Filicineæ, Equisetineæ, and Cycadaceæ, if, indeed, they are not of universal occurrence in the spermatic cells of plants and animals.

WASHINGTON, D. C.

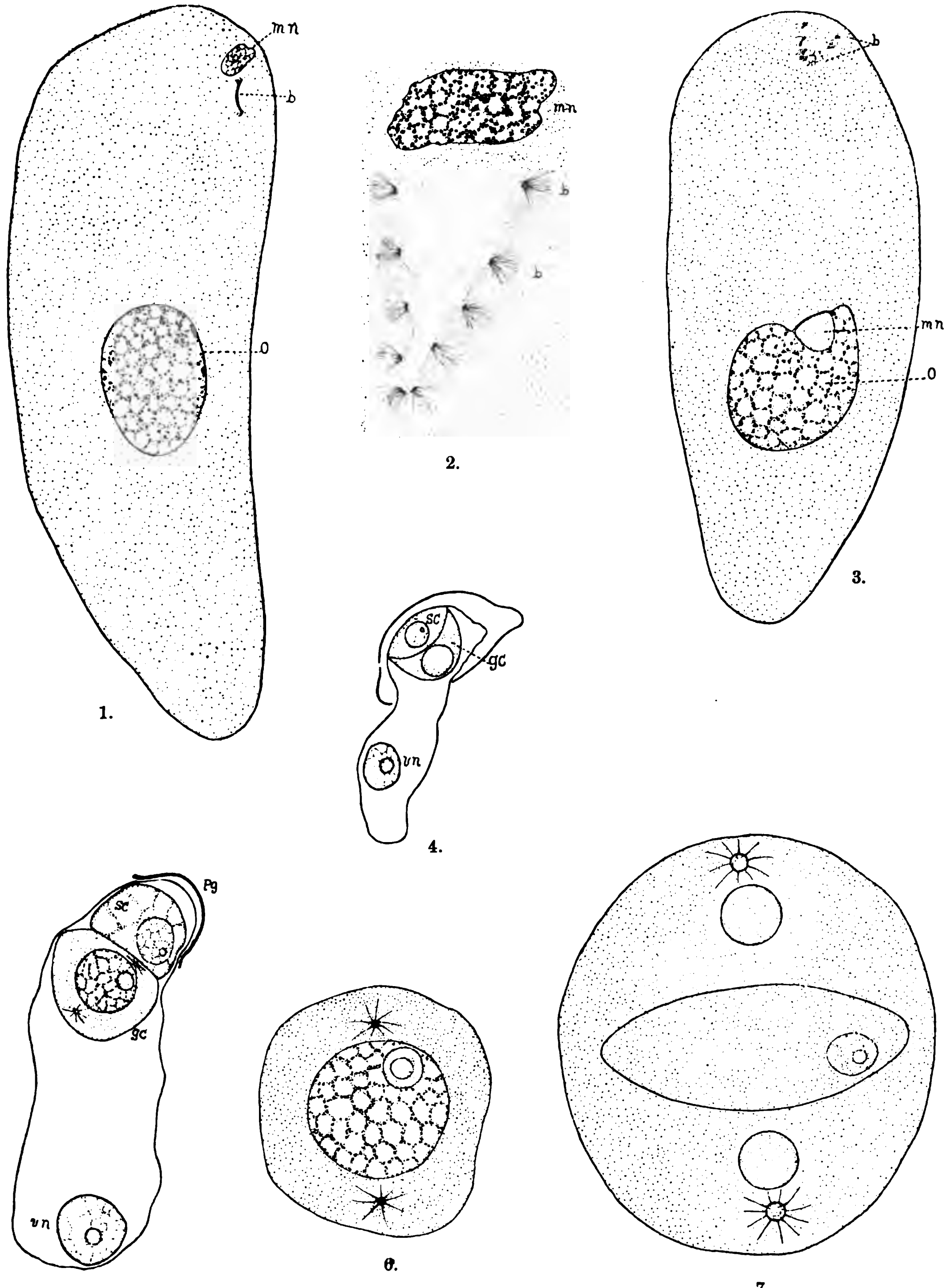
EXPLANATION OF PLATE X.

Zamia integrifolia.

FIG. 1. Archegonium immediately before fecundation by the nucleus of the antherozoid, separated from the ciliiferous band and cytoplasm, lying in the protoplasm at the apex: *o*, oosphere; *mn*, male nucleus; *b*, portion of ciliiferous band. × 30.

FIG. 2. Antherozoid in cytoplasm at apex of the archegonium, with nucleus separated from the ciliiferous band and cytoplasm. × 100.

[16] A more detailed account of Belajeff's discoveries is given under "Notes for Students," p. 302 of this number.



WEBBER on ZAMIA and GINKGO.

FIG 3. Archegonium immediately after fecundation, showing male nucleus (*mn*), in the upper portion of the oosphere; and isolated ciliiferous band of antherozoid producing fecundation at *b*; *o*, oosphere. × 30.

Ginkgo biloba.

FIG. 4. Germinating pollen grain in pollen cavity at apex of nucellus: *gc*, generative cell; *sc*, stalk cell; *vn*, vegetative nucleus. × 500. (From material collected June 12.)

FIG. 5. Germinating pollen grain with generative cell showing blepharoplasts or centrosome-like bodies; *gc*, generative cell; *sc*, stalk cell; *vn*, vegetative nucleus; *pg*, pollen grain. × 500. (From material collected July 27.)

FIG. 6. Generative cell showing blepharoplasts. × 800. (From material collected July 27.)

FIG. 7. Generative cell in a later stage of development, showing the fusiform nucleus and blepharoplasts, and between these the nucleolus-like bodies described by Hirase. × 800. (From material collected August 30.)

NORTH AMERICAN SPECIES OF AMBLYSTEGIUM.

LELLEN STERLING CHENEY.

(WITH PLATES XI–XIII)

INTRODUCTION.

AMERICAN students of bryology have felt for several years that the characterization of the several species of Amblystegium expressed in the descriptions of them now available, are unsatisfactory in many respects. While I was engaged in naming some collections of mosses I met this difficulty and was led to make a closer study of the group, in order, if possible, to discover some clearer diagnostic characters for the several species.

To do such work in the most satisfactory manner the worker should have before him the plants from which the original descriptions were made. Had it been possible for me to prolong this work indefinitely I should have endeavored to see all existing types, notwithstanding the fact that they are widely scattered, and some of them probably available only after months of search. But I have been compelled by circumstances over which I did not have complete control to bring my work to a close without seeing several of the types. In the absence of these, I selected material named by bryologists of recognized ability, compared it carefully with material of other authorities, with the original descriptions and figures, and later ones of good standing, and selected for my descriptions and illustrations those forms which agreed best with the consensus of opinion as expressed in existing descriptions and figures.

In addition to the characters commonly enumerated in descriptions, such as color, general habit, disposition of archegonia and antheridia, I have added some structural characters of both gametophyte and sporophyte, and the averages of a large number of measurements of cells and organs in both.

Such expressions as "a little longer than in the preceding," "shorter than in the former species," etc., are of very little value in the description of any plant, since one man's mole hill may be another's mountain. For the gametophyte I have given the following measurements: length and diameter of stem; length of branches; diameter of central strand when present; diameter of cells in cortex; central strand and ground tissue; dimensions of leaf and leaf cells in three regions, alar, middle, and apical. For the sporophyte measurements were made of the length; the diameter of the seta, its central strand, and the cells of its three tissue regions; the length of the capsule; the dimensions of the exothecium cells and the stomata found on the collum. The averages for the leaf cells were obtained by measuring cells in each of the three regions from five leaves, taking five cells from each region of each leaf. To obtain the average dimensions of leaves a larger number were measured, and for averages of the exothecial cells and those of stomata from ten to twenty or more were measured, whenever there were so many.

In general I have found that the characters of the sporophyte have comparatively little diagnostic value. There are occasional exceptions. For instance, on the collum of the capsule of *A. noterophilum* there are from ninety to two hundred stomata. These are commonly more or less clustered, as many as seven contiguous ones in a single instance being found. In the nearly related species, *A. fluviatile*, the number reaches eighty, while in another related species, *A. irriguum*, the number is usually below forty-five; and in both these species they are scattered.

We must still look to the leaves for the principal characters by which to separate the species. Their shape and size, the size of the cells in the different regions, the presence or absence of a costa and its relative length and diameter are the most available marks. For this reason I have drawn illustrations only of leaves and parts of leaves, with a single exception of *A. noterophilum*. In this case there are no other figures of the capsule known to me.

The student who undertakes the study of Amblystegium must do so with the understanding that he is dealing with a group of exceedingly variable species with many intermediate forms, and must treat them accordingly or meet with disappointment in the end. After long study I am fully convinced that the genus will always prove a troublesome one to the systematist.

HISTORICAL.

The genus Amblystegium was established by Bruch, Schimper, and Gümbel in their *Bryologia Europæa* in 1853, with sixteen species, including *Campylium polygamum* and *Hypnum kneiffii*. Of these, *A. serpens* and *A. riparium* were known to Linnaeus and Dillenius as Hypnum. *A. fluviatile* was described by Swartz in 1799 as *Hypnum fluviatile*, and figured under the same name two years later by Hedwig. Haller described *A. subtile* under the name *H. minimum* in 1768. Hedwig (1801) referred it to Leskea as *L. subtilis*. In this he was followed by Bridel in 1827. *A. confervoides* was described by Bridel in 1812 as *H. confervoides*, and figured by Schwægrichen in 1826 under the name *H. conferva*. *A. radicale* was first described and figured by Hedwig in 1801 as *Leskea varia*, and referred to Amblystegium by Bruch, Schimper and Gümbel, who adopted the specific name applied in 1805 by Palisot de Beauvois to a moss somewhat similar in appearance and supposed to be identical but belonging elsewhere. *A. subenerve*, *A. kochii*, *A. enerve*, *A. oligorrhizon*, *A. curvipes*, and *A. tenuissimum* were established by the authors of the *Bryologia Europæa*. In 1845 Spruce sent a moss to Bruch who in a letter named it *Leskea sprucei*. This is *A. sprucei* of Bry. Eur. *A. irriguum* was described and figured by Wilson in 1855 as *Hypnum irriguum*.

Wilson in the third edition of *Bryologia Brittanica* (1855) did not recognize the genus Amblystegium, choosing to refer the species so named by the authors of Bry. Eur. to Hypnum and Leskea. Schimper however maintains Amblystegium in both editions of his *Synopsis Muscorum Europæorum*, excluding in the first (1860) *A. polygamum*, *A. kneiffii*, and *A. subenerve*,

and adding *A. saxatile* and *A. juratzkanum*. In the second edition (1876) three new species are added, *A. porphyrrhizum* Lindb., *A. leptophyllum* Sch., and *A. hausmani* De Not.; while *A. saxatile* becomes *A. hygrophilum*. In both editions of this work the genus is divided into two subgenera, Amblystegium and Leptodictyum. De Notaris in *Epilogo della Briologia Italiana* (1869) recognizes the genus Amblystegium, but makes it include many Hypna of the Bry. Eur. Milde in *Bryologia Silesiaca* (1869) adopts in all essential features Schimper's conception of the genus, but adds *Hypnum filicinum* Auct. and *H. fallax* Brid. Du Buysson in *Essai analytique du genre Amblystegium* (1883) follows Schimper for generic limits, but reduces several species to varieties. Renauld and Cardot in *Musci Americæ Septentrionalis* (1893) adopt Schimper's limits for the genus. Husnot in *Muscologia Gallica* (1894) does so with Milde's modifications. Dixon and Jameson in *The Student's Handbook of British Mosses* (1896) follow Husnot in large part, but exclude *A. riparium*, which they refer to Campylium. Braithwaite in *British Moss Flora* adopts the limits assigned the genus by De Notaris.

Sullivant in *The Mosses and Hepatics of the United States* (1856) recognizes Amblystegium as a subgenus under Hypnum, adopting in general Schimper's limits, but including *Hypnum polygamum*. In *Icones Muscorum* (1864) Amblystegium is still considered a subgenus of Hypnum. In Lesquereux and James' *Mosses of North America* the arrangement of Sullivant is followed, with the exception of *H. polygamum*, which is placed under the subgenus Campylium. Austin in *Musci Appalachiani* (1870) follows Schimper, but reduces many species of the latter and other authors to the rank of varieties. Macoun and Kindberg in *Catalogue of Canadian Plants* likewise follow Schimper.

GENERIC LIMITS.

To me the generic limits established by Schimper appear to be the most natural ones. As thus defined, the genus includes at least two species, *A. riparium* and *A. vacillans*, whose leaf

structure, considered alone, might place them elsewhere; but when account is taken of the sum of their characters, they must be referred to Amblystegium. I cannot agree, therefore, with Messrs. Dixon and Jameson, who, in their recent admirable *Handbook*, have placed the former in the genus Campylium. Nor can I accept the inclusion of *Hypnum filicinum* and its near relatives in Amblystegium by Husnot in *Muscologia Gallica*, in which he is followed by Dixon and Jameson. Here again the sum of the characters should decide the position of the plant. It appears to me that the very general hypnoid facies, the paraphyllia and the inflated alar cells, together with leaf cells otherwise not entirely of the Amblystegium type, ought to exclude it.

De Notaris, Mitten, Kindberg, and Braithwaite extend the limits of the genus so as to include several other groups of the Hypnaceæ. With these proposals I cannot agree unless we are content to go back to the comprehensive idea of the genus Hypnum. Should I go as far as these authors propose, I can see no reason why I should not include all the Hypnaceæ. The species of Limnobium, for example, are, I think, quite as closely related to the plants included by Braithwaite in Eu-Amblystegium as are the species of Calliergon, which he refers to Amblystegium. Yet the Limnobia are not included.

DISTRIBUTION.

I have been able to separate sixteen species. Ten of these are found both in Europe and North America. Five others, *AA. minutissimum, lescurii, compactum, noterophilum,* and *vacillans,* are exclusively North American. The sixteenth, *A. adnatum,* is found in North America and Japan. Of these, three, *AA. serpens, varium,* and *riparium,* are found in most parts of the United States and southern Canada, the first being less common than the others. *A. adnatum* is widely distributed, though not abundant, in the southeastern United States. *A. compactum* may be considered northern, though it extends south in the Rocky mountains to Colorado; *A. sprucei* has a similar distribution, though not found at as many stations; *A. fluviatile,* so far as

known, is northeastern, extending west to Minnesota, and south to Ohio and New Jersey. *A. lescurii* is Appalachian in its range. *A. kochii*, although represented in herbaria from few stations, seems to be widely distributed, being reported from Kansas, Minnesota, and the District of Columbia. *A. vacillans* appears to be eastern and northern, probably local; *A. minutissimum* is central and probably local; the other four are northern. One striking feature in this distribution is the entire absence of any distinctly southern or western forms, though the south has a good variety in *A. riparium floridanum*. It is hardly credible that there is such a dearth of Amblystegia in these regions as appears. No doubt further exploration in the west and south would reveal several forms.

RELATIONSHIPS.

The sixteen species here included fall into three groups, the type group of twelve species of which *A. serpens* is the center, and two small groups. One of these smaller groups contains a single species, *A. lescurii;* the other is made up of *A. riparium* and its varieties, *A. kochii*, and *A. vacillans.*

EXCLUDED SPECIES.

Several species accredited to North America have been excluded in this paper, because with the available material I have not been able to separate them from older species here given. *A. fenestratum* M. & K. is probably not an Amblystegium. It was described from a scrap of sterile gametophyte. *A. speirophyllum* M. & K., also sterile, is probably a form of *A. irriguum* or *varium; A. distantifolium* M. & K. is very near *A. irriguum; A. dissitifolium* M. & K. and *A. subcompactum* are, without doubt, *A. compactum. A. holzingeri* R. & C. is *Hypnum* (*Limnobium*) *closteri* Austin. *A. schlotthaueri* was allowed by me to stand in Barnes & Heald's *Key* as a subspecies, but on further comparison with *A. serpens*, I have been unable to separate it from that species. I have not been able to see *A. homalostegium* Jaeg. & Sauerb., a plant collected but once, in Alabama; but from the description

it is so doubtful as an Amblystegium that I have omitted it. *A. curvipes* Bru. & Sch., so far as N. American plants are concerned, must be referred to *A. kochii;* likewise all of the N. American specimens of *A. hygrophilum* Sch. that I have seen are referable either to *Hyp. chrysophyllum* or to *H. radicale* P. B. Some European specimens under the name *A. hygrophilum* must also be referred to Beauvois' plant, which now proves from the type material to be identical with Austin's *Hyp. bergenense* = *H. chrysophyllum*, var. *tenellum* of the L. & J. Manual. These plants are both decidedly nearer Campylium than Amblystegium, and I therefore place them there under Beauvois' old name. I am of the opinion that *A. hygrophilum*, and possibly *A. porphyrrhizum* as well, must be put with *H. radicale*. However, all the material of *A. porphyrrhizum* that I have had an opportunity to examine is only a form of *A. varium*. *A. orthocladon* P. B., from his type material, is *A. fluviatile* Sw. The disappearance of *A. orthocladon* from the list of species of Amblystegium removes one of the worst tangles in the genus. Illustrations and descriptions of Beauvois' types will appear elsewhere at a later date.

NOMENCLATURE.

For nomenclature I have gone back only to Hedwig's *Muscorum Frondosorum*. I do this because of a quite general disposition to make this work the starting point for the nomenclature of the Musci. If the *Species Plantarum* of Linnaeus is to be considered the datum line for all plants, then the name of Linnaeus should take the place of the name in parenthesis after *A. serpens* and *A. riparium*. In the list of works cited in the bibliography, I have included but three prior to the date of *Muscorum Frondosorum*.

ACKNOWLEDGMENTS.

I hope this paper may be the means of clearing up some, at least, of the difficulties attending the study of this genus even by bryologists. Aside from my own efforts, whatever of value it

may have is due to the kind cooperation of friendly bryologists. I gladly acknowledge the assistance thus received from many sources, without which my study would have been impossible, and here express my sense of indebtedness and my thanks for this assistance. Professor Charles R. Barnes of the University of Wisconsin, by giving to me at all times without stint his kindly interest and help in manifold ways, as well as by commanding for my use all the facilities in the power of the University for carrying on my work,[1] has placed me under the greatest obligations. To Mrs. Elizabeth G. Britton of New York, for the use of Amblystegium material in the Columbia University Herbarium, which she placed entirely at my command, and for many other favors; to Professor John Macoun of Ottawa, Ontario, for specimens of several forms not elsewhere available; to Professor John M. Holzinger, of Winona, Minnesota, for the use of type and other specimens; to M. Jules Cardot, of Stenay, France, for material; to Dr. B. L. Robinson, of Harvard University, for type specimens; and to Mr. Frederick V. Coville, of Washington, D C., for books loaned, I offer my sincerest thanks.

AMBLYSTEGIUM Br. & Sch.

Amblystegium Bry. Eur. Monog. Amblystegium. 1853.
Hypnum pp. plur. auct.
Leskea pp. plur. auct.

Gametophyte bisexual rarely unisexual, varying in size from very minute to very large and robust; bright green, dark dull green, yellowish green to yellow or sometimes bronze; prostrate, creeping, decumbent, ascending or erect: stems for the most part slender, soft, occasionally rigid; abundantly and commonly irregularly branched, rarely subpinnate; with or without central strand; sometimes obscurely angled; branches flexuous, ascending or erect: leaves five to eight-ranked, generally spreading

[1] Among the type material which I have consulted none was more useful than specimens from the herbarium of Palisot de Beauvois. All his American types have been sent to the University of Wisconsin for examination through the courtesy of Dr. J. Briquet, curator of the Delessert Herbarium of Geneva, Switzerland. These types will all be studied and illustrated by figures in the course of a few months.

in all directions, sometimes complanate; widely spreading to strict; narrowly lanceolate to broadly ovate, concave or flat, never auriculate or with cells abruptly inflated at the angles, more or less decurrent, wings commonly adhering to the stem when the leaves are separated; ecostate to strongly costate, costa varying from a mere trace at the base to one-third the width of the leaf and long excurrent; margins entire to serrate; cells in the middle leaf region varying from 1:2 to 1:15, hexagonal or rhomboidal, at the leaf base broader and quadrate to long rectangular.

Sporophyte minute to large, 5^{mm} to 4^{cm} long, abundant in most species: seta generally, slender, flexuous, smooth, varying from straw color to dark purple, becoming dull dirty brown with age, central strand well developed: capsule oval to cylindrical, symmetric or asymmetric, erect incurved or horizontal, ordinarily constricted under the mouth in drying, from a large or small collum, uniformly purple or brown, or of two shades, dark on convex side and light on concave side, or pale throughout; exothecium of soft tissue; peristome hypnoid, cilia in a few cases none or rudimentary, usually two to four; operculum convex to conic, usually obtusely apiculate, rarely rostellate; annulus of one to three rows of cells; spores minutely roughened, 12 to 30μ in diameter: calyptra small, fugacious.

ANALYTICAL KEY TO THE SPECIES.

I. *Leaves ecostate or with obscure traces of a nerve.*

Alar cells oblong to linear.
  Leaf entire at base, triangular lanceolate . . *A. minutissimum.*
  Leaf papillosely serrulate over transverse cell walls, ovate, long acuminate . . . . *A. sprucei.*
Alar cells quadrate or transversely elongated.
  Plants minute ($1–2^{cm}$)
    Leaves ovate, acuminate, cells irregular, short 1 : 2 or less. *A. confervoides.*
    Leaves lanceolate, long acuminate, cells regular, 1 : 3 or more in the middle and apical regions . . . . . . *A. subtile.*
  Plants twice as large or more . . . . . . *A. adnatum.*

II. *Leaves plainly costate.*

A. *Leaves with a distinct border.*

Costa joining border at apex . . . . *A. lescurii.*

B. *Leaves not bordered.*

* *Costate to apex or nearly so.*

Leaves acuminate, basal cells abruptly enlarged . . *A. irriguum.*
Leaves acuminate, basal cells not enlarged.
  Serrate throughout . . . . *A. compactum.*
  Entire, or obscurely serrulate above.
    Acumen long, costa ceasing within it . . . *A. varium.*
    Acumen short, costa very strong, usually long excurrent. *A. noterophilum.*
Leaves not acuminate, ovate to oblong lanceolate, tip blunt *A. fluviatile.*

* * *Costa disappearing at the middle or above.*

[*A. compactum* may be sought here.]

Cells near the middle of the leaf 1 : 10–15.
  Leaves long acuminate, apex sharp . . . . . *A. riparium.*
  Leaves acute or short acuminate, apex blunt . . . *A. vacillans.*
Cells near the middle of the leaf 1 : 8 or less.
  Alar cells quadrate or transversely elongated . . . *A. serpens.*
  Alar cells oblong.
    Leaves 0.9–1.2×0.25–0.37^{mm} . . . . *A. juratzkanum.*
    Leaves 1.2–1.6×0.5 –0.7^{mm} . . . . . . *A. kochii.*

AMBLYSTEGIUM MINUTISSIMUM (S. & L.) Jaeg. & Sauerb. *Plate XI. fig. 4.*

SYNON.: *Hypnum minutissimum* Sulliv. Musci and Hepat. of U. S.—(78) (issue of 1871). 1856.—Sulliv. & Lesq. Icon. Musc. 195. *pl. 120.* 1864.—Lesq. & James Man. Mosses of N. Am. 371. 1884.

Amblystegium minutissimum Jaeg. & Sauerb. Adumb. 2 : 547.—.—Macoun & Kindberg Cat. Can. Pl. 6 : 216. 1892.

EXSICCATI: *Hypnum confervoides* Sulliv. Musci Allegh. 31 (in part). *Hypnum minutissimum* Sulliv. & Lesq. *Musci Bor. Amer.* (1st ed.) 343. (2d ed.) 520 (Herb. Wis.).

TYPE *in Herb. Sulliv.*, Cambridge, Mass.

Gametophyte bisexual, *very minute*, pale green : stems prostrate, appressed, irregularly subpinnately branched, cylindrical, 60 to 110 μ in diameter; central strand none; cortical region of one to two layers of cells, not well differentiated, walls thin, cells

6 to 8μ in diameter; cells of ground tissue 8 to 29μ diameter; branches short, 2.5 to 5^{mm}, erect or spreading: *leaves linear lanceolate*, 90μ wide by 340μ long, varying in width from 70 to 105μ and in length from 280 to 400μ, *usually widest at very base*, tapering regularly to apex, point slender, entire at base, subdenticulate from below the middle to the apex or distinctly denticulate in the upper third, remote, open, spreading in all directions, ecostate or with a second layer of cells in costal region of basal fifth; leaf cells parenchymatous at base, soon becoming prosenchymatous above, *short rectangular in alar region*, averaging 7.5 by 18μ, shorter near the middle of base, occasionally quadrate, 6.7μ in diameter, becoming linear toward middle of the leaf, 5.6 by 40μ, occasionally reaching the extreme length of 60μ, rectangular, rhombic quadrangular or hexagonal; above the middle all prosenchymatous, many slightly vermicular, in the apical region shorter, 5.6 by 34.5μ, occasionally reaching 42μ in length; perichætial leaves long acuminate from an ovate base, coarsely and irregularly dentate above, inner larger than stem leaves, reaching 200μ wide by 750μ long.

Sporophyte small, 5^{mm} long: seta reddish brown below, pale above, 70 to 80μ in diameter, central strand of few rows of cells 15 to 18μ in diameter, cortex of one or two layers of cells 6 to 18.5μ in diameter, cells of ground tissue 9 to 17μ: capsule minute, 0.5^{mm} in length including the operculum, straight or slightly cernuous, oval, occasionally obovate, 1:2, erect, inclined or pendulous, strongly contracted under the mouth, when dry turbinate; cells of exothecium parenchymatous, regular, short rectangular, quadrate, or slightly transversely elongated, average size 20μ wide by 23μ long, walls thin, 1 to 2.5μ thick, two or three rows of cells under the peristome transversely elongated, 18 by 11μ; stomata few, two to six, 21.5μ wide by 26μ long: peristome teeth pale with narrow hyaline border, transversely striate on the back of lower three-fifths, hyaline and papillose above; endostome equaling teeth, membrane about one-half the length of segments, the latter slender, pale, not open along the keel, finely papillose, as are the 1 or 2 slender nodose cilia which equal the segments;

operculum high conic or rostellate from a conic base; annulus of one or two rows of cells, persistent: spores pale, minutely roughened, 8 to 13μ in diameter: calyptra not seen.

HAB.: Growing on limestone rocks in shaded ravines, forming thin, loose patches over the substratum; in company with *Thuidium pygmæum*. Type locality, central and southern Ohio.

Northeastern U. S.: Ohio (Sullivant), Penn., very rare.

A very delicate plant, easily confounded with *A. sprucei* and *A. confervoides*. The leaf characters alone, however, should in most cases be sufficient to separate these three species. In *A. confervoides* the leaf cells are comparatively short and irregular throughout, with a large number in the alar regions quadrate or triangular; while in *A. minutissimum* the leaf cells are much elongated throughout, with the longest cells in the middle of the leaf. *A. sprucei*, while its leaf cells are decidedly elongated throughout, is distinguished from *A. minutissimum* by the leaves papillosely serrulate at base with the longest cell at the very apex. Further, both *A. confervoides* and *A. sprucei* have the widest point of the leaf some distance above the line of insertion, while in *A. minutissimum* the widest point is at the line of insertion, in most cases.

AMBLYSTEGIUM SPRUCEI (Br.) Br. and Sch. *Plate XI. fig. 2.*

SYNON.: *Leskea sprucei* Bruch (*in litt.*) 1845. — Spruce, Lond. Jour. Bot. 180. 1845. — Wilson, Bry. Brit. 330. 1855 (3 ed.).

Hypnum sprucei Bruch (*in litt.*) 1845. — C. Mueller, Syn. Musc. Frond. 2: 415. 1851. — Lesq. & James, Man. Moss. N. Am. 372. 1884.

Amblystegium sprucei Bruch & Schimper, Bry. Eur. Amblystegium 5, *pl. 1.* 1853. — Schimper, Syn. Musc. Eur. 588. 1860 (1st ed.); 705. 1876 (2d. ed.). — Milde, Bry. Siles. 322. 1869. — Hartmann, Handb. Skand. Flora 21. 1871 (10th ed.). — Hobk. Synops. 163. 1873. — Lindberg, Musci Scand. 32. 1879. — R. du Buysson, Essai analyt. du genre Amblystegium. 1883. — Boulay, Musc. Fr. 82. 1884. — Mac. & Kindb. Cat. Can. Pl. 6: 217. 1892. — Husnot, Musc. Gall. 356. *pl. 102,* 1893. — Dixon & Jameson, Handb. Brit. Mosses 441, *pl. 55.* 1896. — Braithwaite, Brit. Moss Flora. 3: 28. *pl. 89.* 1896.

Platydictya sprucei Berkeley, Handb. Brit. Mosses 145. 1863.

EXSICCATI: *Hypnum confervoides* Drummond, Musc. Amer. (Coll. I) 190.

Hypnum sprucei Macoun, Can. Musc. 315 (Herb. Wis.).

TYPE in herb. Bruch, Berlin?

Gametophyte unisexual, minute, slender, densely cespitose, tufts bright green above, not shining, becoming yellow with

age: stems creeping and copiously irregularly branched, cylindrical, 60 to 100μ in diameter; central strand none; cortex of one to two layers of thick walled cells, 5 to 8.4μ in diameter; cells of ground tissue thin walled, 6.5 to 13μ in diameter; branches simple or with few branchlets, 0.5 to 1μ in length, ascending: leaves *lanceolate ovate-lanceolate or ovate*, mostly long acuminate, point very slender, average size 90 by 225μ, varying in length from 100 to 400μ and in width from 60 to 120μ, widest in basal sixth *generally above the line of insertion*, denticulate or subdenticulate to base, *teeth in lower part of leaf formed by single or double papillæ over the transverse walls*, open erect, equally spreading, not appressed but slightly crisped when dry, usually remote, occasionally crowded, ecostate; leaf cells parenchymatous at base, prosenchymatous above, occasionally quadrate, generally long rectangular in alar region, *papillose on the margin over transverse walls*, 8.2μ wide by 12.7μ long, ranging in width from 5 to 9μ and in length from 5 to 22μ, hexagonal to linear-hexagonal in the middle of the leaf, occasionally long rectangular or rhomboidal in the margin, 7μ wide by 27μ long, varying in width from 4 to 8.5μ and in length from 17 to 45μ, linear at apex, 5.5μ wide by 32μ long, varying in width from 4 to 7.7μ and in length from 21.5 to 52μ, apical cell of leaf in most cases the longest; perichætial leaves ovate-lanceolate, acuminate, point filiform, irregularly ciliate dentate, reaching 1^{mm} in length, ecostate, cells short rectangular at base, linear and sometimes slightly vermicular above.

Sporophyte small, 1 to 1.5^{cm} long, *reddish purple throughout at maturity*, fading with age: seta 100 to 120μ in diameter, cortex of one to two layers of well differentiated cells 5 to 9μ in diameter; central strand 12 to 28μ in diameter, composed of 15 to 25 rows of cells; cells of ground tissue 6.5 to 13μ in diameter, walls strongly thickened: capsule symmetric, rarely slightly asymmetric, erect or suberect, subglobose to ovate, 0.5 to 1.5^{mm} long by 0.25 to 5^{mm} wide, slightly or not constricted under the mouth when dry, funnelform; cells of exothecium parenchymatous, regular or irregular, triangular to hexagonal, varying from

oblong (1 : 2.5) to slightly transversely elongated (1.25 : 1), averaging isodiametric (26μ), cell walls 4 to 6μ thick, three to five rows of cells immediately below peristome with thin walls and transversely elongated, 28.8μ wide by 11μ long; stomata five to twelve, scattered, 27.5μ wide by 31.5μ long; peristome one-fourth to one-third length of sporangium, teeth pale yellow, soon becoming hyaline, transversely striate on the back in the lower two-thirds, minutely papillose above; membrane of endostome equaling segments, the latter slender, not open along the keel, equaling the teeth, sparsely papillose; cilia one or two, short, one-third the length of segments, or none; operculum large, hemispherical, mamillate, annulus of one or rarely two rows of cells: spores pale, slightly papillose, 9 to 13μ in diameter: calyptra small, split one half its length.

HAB.: On shaded rocks, earth, twigs, and decaying logs. Type locality, Pyrenees.

Europe, North America: Ontario, mountain region of Canada, Massachusetts, Montana, Idaho, Colorado, New Mexico. Not uncommon locally.

This little moss was first collected by Drummond in Canada and Blytt in Norway, but in both cases it was called *A. confervoides*. As we now know these plants there is little difficulty in distinguishing them by their microscopic leaf characters alone. *A. sprucei* is serrulate throughout and *A. confervoides* entire; the former has elongated cells in the alar regions and linear ones at the apex, while the latter has much shorter cells throughout, being isodiametric in the alar regions and about 1 : 2 at the apex. The leaf characters distinguishing *A. sprucei* from *A. minutissimum* have already been pointed out.

AMBLYSTEGIUM CONFERVOIDES (Brid.) Br. & Sch. *Plate XI. fig. 1.*

SYNON.: *Hypnum confervoides*, Bridel, Spec. Musc. 2: 153. 1812. Mant. Musc. 167. 1819. Schwægrichen, Spec. Musc. Suppl. 1. 2: 218. 1816.—Funcke, Moost. 58, *pl. 39.* 1820.—Huebener, Muscol. Germ. 667. 1833.—De Notaris, Syllabus Musc. 11. 1838.—Rabenhorst, Deutschland's Krypt. Flora 2[3]: 292. 1848.—C. Mueller, Syn. Musc. Frond. 2: 414. 1851. Deutschland's Moose 453. 1853.—Hobkirk, Synop. 163. 1873.—Boulay, Musc. Fr. 80. 1884.—Lesq. & James, Man. Moss, N. Am. 372. 1884.

Hypnum conferva Schwaegr. Spec. Musc. Suppl. 2, 1: 158, *pl. 142.* 1823.

Hypnum jungermanioides Bridel, Bry. Univ. 2: 549. 1827.

Hypnum stereodon confervoides Bridel, Bry. Univ. 2:583. 1827.

Leskea confervoides Spruce, Lond. Jour. Bot. 4:182. 1845.

Amblystegium confervoides Bruch and Schimper, Bry. Eur. Ambly. 6. *pl. 2.* 1853.—Schimper, Syn. Musc. (1st ed.) 590. 1860. (2d ed.) 707. 1876.—Milde, Bry. Siles. 323. 1869.—DeNotaris, Epi. Bry. Ital. 156. 1869.—Hartmann, Skand. Flora. (10th ed.) 21. 1871.—R. duBuysson Ess. anal. 9. 1883.—Hobkirk, Synop. (2d ed.) 212. 1884.—Macoun & Kindberg, Cat. Can. Pl. 6: 218. 1892.—Husnot, Musc. Gall. 357. *pl. 102.* 1892.—Dixon & Jameson, Stud. Handb. 442. *pl. 55.* 1896.—Braithwaite, Brit. Moss Fl. 3: 27. *pl. 89.* 1896.

EXSICCATI: *Amblystegium confervoides* Austin, Musc. Appl. 368 (Herb. Wis.).

Hypnum minutissimum Sulliv. & Lesq. Musc. Bor. Am. (2d ed.) 520 (Herb. Columbia Univ. in part).

Hypnum confervoides Macoun Can. Musci. 317 (Herb. Wis.).

TYPE in Herb. Bridel.

Gametophyte bisexual, small, cespitose, in thin closely adhering patches, dark green: stems very slender, 60 to 90μ in diameter, not angled, closely and subpinnately branched; branches 0.5 to 1^{cm} long, erect or ascending; central strand none; cortex of two layers of cells, 4.5 to 10.5μ in diameter, differentiated from ground tissue only by the size of cells, those of the latter tissue 9 to 14μ in diameter, thick walled: leaves remote, ovate to ovate lanceolate, 105μ wide by 255μ long, varying in width from 80 to 130μ and in length from 200 to 300μ, attaining their greatest width in the basal sixth but above the line of insertion, straight or rarely falcate, acute or acuminate, *acumen usually stout*, erect spreading, appressed when dry, margin entire, rarely irregularly subdenticulate, ecostate; leaf cells parenchymatous at base and in the margins in the lower half, prosenchymatous in median portion of lower half and throughout all of the upper half, cells in alar region *irregular, quadrate, triangular, or slightly transversely elongated, about three rows extending up the leaf five to ten cells*, 8.2μ wide by 7.5μ long, varying from 7 to 10.3μ long and from 6 to 9.4μ wide, cells above becoming elongate rectangular (1:2–4), cells in the median and apical regions sometimes regular, oval to elliptical hexagonal, more or less flexuose, *oftener irregular, oval, triangular, hexagonal, or rhomboidal*, 7μ wide by 21.5μ long,

ranging in length from 15 to 28μ and in width from 4 to 10.5μ; perichætial leaves elongate lanceolate from a broadly ovate base, abruptly contracted above into a narrow acumen which varies in length from one half the body of the leaf to its full length, denticulate especially at the base of the acumen, ecostate or with very narrow thin costa in the lower third.

Sporophyte small, .75 to 1.5^{cm} long: seta reddish-brown, 90 to 120μ in diameter, cortex of one or two layers of cells 4 to 10μ in diameter, central strand composed of twelve to twenty-five rows of cells 15 to 30μ in diameter, capsule symmetric or slightly asymmetric, suberect to almost horizontal, ovate or cylindrical, not contracted below mouth when dry, incurved, dark dull brown; exothecium cells parenchymatous, oblong rectangular, 21.5μ wide by 34μ long, varying from 13 to 26μ wide and from 17 to 43μ long, lateral walls 3 to 6μ thick, three rows of cells below the mouth hexagonal isodiametric or transversely elongated (17μ); stomata few, six to ten, scattered, 28.5μ wide by 31μ long; teeth of peristome yellow with narrow hyaline border striæ, on the back transverse in the lower three-fourths, above this oblique or longitudinal, giving place finally to rows of long papillæ; endostome light yellow, membrane occupying more than half its entire height; segments strongly carinate, opened slightly along the keel between the articulations, finely papillose, not equaling the teeth, cilia one or two, generally shorter than the segments, sometimes not more than one-third their length; operculum apiculate from a convex or conic base, usually as broad as the capsule; annulus of one or two rows of cells: spores pale, finely tuberculate, 8.5 to 15μ in diameter: calyptra usually shorter than capsule, split little more than half its length.

HAB.: On bowlders in moist woods or on shaded moist limestone cliffs. Type locality Austria.

Europe, Asia, North America: New England, New Brunswick, Ontario, Ohio, along the great lakes, and Rocky mountains. Not abundant.

A small plant, very generally confused with *A. sprucei* and *A. subtile* by American collectors and writers. From the former it may usually be readily

distinguished by characters referred to under that species; from the latter it is distinguished by its smaller cells in the alar region and shorter and more irregular cells in the middle and apical regions. Further, *A. subtile* shows a distinct trace of costa in most leaves and has its parts in general one-half larger.

AMBLYSTEGIUM SUBTILE (Hedw.) Br. & Sch. *Plate XI. fig. 3.*

SYNON.: *Hypnum minimum* Haller, Hist. Stirp. Helvet. 1768.

Leskea subtilis Hedwig, Musc. Frond. 4: 23. *pl. 9.* 1797. Sp. Musc. 221. 1801.—Swartz, Musci. Sueciæ 69. 1799.—Roth, Fl. Germ. 3: 335. 1800.—Bridel, Musc. Recent. 3: 44. 1801. Bry. Univ. 2: 309. 1827.—Weber & Mohr, Bot. Tasch. 250. 1807.—Rœhling, Deutschl. Flora (2d ed.) 3: 87. 1813.—Wahlenberg, Fl. Carpat. 356. 1814.—Schwægrichen, Sp. Musc. Suppl. 1. 2: 176. 1816.—Martius, Flora crypt. Erlang. 48. 1817.—Funck, Deutsch. Moos. 55. *pl. 36.* 1820.—Hübener, Musc. Germ 587. 1833.—DeNotaris, Syl. Musc. Ital. 62. 1838.—Hartmann, Skand. Fl. (10th ed.) 21. 1871.

Hypnum subtile Hoffmann, Deutschl. Flora 2: 70. 1796.—Smith, Flora Brit. 3: 1277. 1804.—Palisot de Beauvois, Prodrome 71. 1805.—C. Mueller, Syn. Musc. Frond. 2: 415. 1851. Deutsch. Moos. 454. 1853.—Sullivant, Musci and Hepat. of U. S. 77. 1856.—Lesq. & James, Man. Moss. N. Am. 372. 1884.

Neckera tenuis Bridel, Mant. Musc. 138. 1819.

Hypnum (*Stereodon*) *serpens* var. *subtilis* Bridel, Bry. Univ. 2: 649. 1827.

Amblystegium subtile Bruch & Schimper, Bry. Eur. Ambly. 4. *pl. 1.* 1853.—Schimper, Synop. Musc. Eur. (1st ed.) 589. 1860. (2d ed.) 706. 1876.—Milde, Bry. Siles. 322. 1869.—DeNotaris, Epil. Bry. Ital. 155. 1869.—Hartmann, Skand. Fl. (10th ed.) 21. 1871.—Lindberg, Musc. Scand. 32. 1879.—R. du Buysson, Ess. Anal. 1883.—Macoun & Kindberg, Cat. Can. Pl. 6: 217. 1892.—Husnot. Musc. Gall. 356. *pl. 102.* 1894.

EXSICCATI: *Hypnum subtile* Sull. & Lesq., Musc. Bor. Amer. (1st ed.) 342. (2d ed.) 519.—Macoun, Can. Musc. 316. (Herb. Wis.).

Amblystegium subtile Austin, Musc. App. 369. (Herb. Wis.).

TYPE in herb. Haller, Berne, Switzerland.

Gametophyte bisexual, small, widely cespitose, dark green, coherent in tangled felts: stems repent, slender, 60 to 110 μ in diameter, 1 to 3^{cm} long, radiculose to the apex, branched, cylindrical; central strand none; cortex of one or two layers of small cells 6.5 to 10.7 μ in diameter; cells of ground tissue 13 to 21.7 μ in diameter, largest at the center, cell walls uniformly thickened in all tissues with the occasional exception of cells in the outer cortical layer where the wall is thin; branches

numerous, short, 0.5 to 1^{cm} long, erect: leaves not crowded, lanceolate from an ovate base, sometimes linear-lanceolate, *long acuminate*, acumen very slender, 130 μ wide by 440 μ long, ranging in width from 100 to 150 μ and in length from 250 to 500 μ, reaching greatest width in basal fifth, but some distance above the line of insertion, straight or more or less falcate, equally spreading, suberect or subsecund, appressed when dry except the slender points, *entire, with only a trace of costa in basal fifth, this sometimes double or branching* or very rarely wanting; leaf cells parenchymatous at base and along margins in lower half, elsewhere prosenchymatous, *cells at basal angles regular, quadrate or slightly transversely elongated, becoming short rectangular toward the middle, 11 μ wide by 9.5 μ long*, varying in width from 8.5 to 16 μ, and in length from 6.5 to 15 μ, cells in the middle of the lower third oblong, about 1:1.5, those of the middle region irregularly hexagonal, occasionally slightly flexuose, 8.2 μ wide by 26 μ long, ranging in width from 6.5 to 10 μ and in length from 19 to 32 μ, cells in apical region much as in median region, but regularly somewhat longer, the terminal cell in most cases being the longest in the leaf blade, varying in width from 6.5 to 9.5 μ and in length from 15 to 44 μ, averaging 8 μ wide by 30.5 μ long; outer perichætial leaves abruptly long acuminate from a broadly ovate base, acumen equaling the body, ecostate or with a trace of costa at base, inner leaves much larger, linear lanceolate, abruptly acuminate, acumen one-half the length of the body, costate to middle or beyond, costa thin but distinct, all entire.

Sporophyte small, 1^{cm} long, cinnamon brown: seta flexuous in upper third, 120 to 150 μ in diameter, central strand 16 to 19 μ in diameter, composed of ten to eighteen rows of cells, cortex of two or three layers of cells, with walls moderately thickened, 6.5 to 13 μ in diameter, cells of ground tissue 13 to 21.5 μ in diameter, largest near the central strand: capsule oblong cylindrical, 1 to 1.5^{mm} long including operculum, symmetric or moderately incurved, erect, becoming more or less inclined by the bending of the seta, only slightly contracted under the mouth in drying, collum shrivelling and becoming wrinkled, wall of

capsule thin and flaccid, cells of exothecium parenchymatous, varying from quadrate to oblong, 22 μ wide by 46 μ long, varying in width from 13 to 26 μ and in length from 21 to 80 μ, walls uniformly thickened, 4 μ, three to five rows of cells below the mouth hexagonal, 13 to 21.5 μ in diameter, stomata eight to fifteen, scattered, 27 μ wide by 35 μ long; peristome teeth pale yellow with hyaline border, lance-linear, striæ on the back transverse in lower two thirds, oblique above or replaced by irregularly scattered papillæ, endostome equaling the teeth, one-third to one-half the length of the segments, the latter linear, carinate, open along the keel between the articulations, sparsely papillose, cilia very rudimentary or none, operculum high convex to conic, obliquely apiculate; annulus of one or two rows of cells: spores pale, 10 to 16 μ in diameter: calyptra equaling the capsule, split more than half its length.

HAB.: On bases of tree trunks, chiefly maple, beech and willow; rarely on shaded rocks. Type locality Switzerland.

Europe, Asia, North America: New England, New York, New Jersey, Ontario, and westward along the Great Lakes to Wisconsin and Minnesota. Not rare.

This with the preceding three species, on account of their uniformly small size, form a group, all of which are usually easily distinguished from all other members of the genus, though small forms of *A. adnatum* and *A. serpens* may sometimes be mistaken for them. The former has leaves proportionately broader, more abruptly and shorter pointed, with cells very regular and uniformly larger in upper parts of leaf. The latter usually shows a distinct costa in the lower third of the leaf.

AMBLYSTEGIUM ADNATUM (Hedw.) Aust. *Plate XI. fig. 5.*

SYNON.: *Hypnum adnatum* Hedwig, Spec. Musc. 248. *pl. 64. f. 5–10.* 1801.— Palisot de Beauvois, Prodr. 61. 1805.— Bridel, Spec. Musc. 2: 160. 1812. Mant. Musc. 168. 1819.— Schwægrichen, Spec. Musc. Suppl. 1. 2: 215. 1816.— C. Mueller. Syn. Musc. Frond. 2; 339. 1851.— Sullivant, Musc. and Hepat. of U. S. 78. 1856. Icon. Musc. 197. *pl. 121.* 1864.— Lesquereux & James, Man. Moss. N. Am. 375. 1884.

Hypnum (*Stereodon*) *adnatus* Bridel, Bry. Univ. 2: 591. 1827.

Amblystegium adnatum Macoun & Kindberg. Cat. Can. Pl. 6: 220. 1892.

EXSICCATI: ***Hypnum adnatum*** Sulliv. & Lesq., Musc. Bor. Amer. (1st ed.) 344. (2d ed.) 521, 522.— Macoun, Can. Musc. 322, 323 (Herb. Wis.).

Amblystegium adnatum Austin, Musc. App. 370. 1870.

TYPE in Herb. Hedwig.

Gametophyte bisexual, depressed, in wide thin mats, yellowish, pale green or sometimes dark green, closely adhering to the substratum: stems irregularly branching, creeping, 2 to 4^{cm} long, slightly flattened, the two diameters usually 4:5, 140 by 175 μ in diameter, ranging from 100 by 125 μ to 180 by 225 μ; central strand none; cortex of three or four layers of cells, 6.5 to 14 μ in diameter; cells of ground tissue 10 to 22.5 μ, largest near the center, cell walls noticeably thickened; branches numerous, very short, 2 to 5^{mm}, erect: leaves crowded, erect spreading, *ovate or oblong, abruptly short acuminate, acumen broad*, concave, *entire* or occasionally irregularly denticulate, *usually with a thin simple branched or double costa in basal fifth*, 345 μ wide by 820 μ long, varying in width from 300 to 380 μ and in length from 800 μ to more than a millimeter; leaf cells in all but alar regions prosenchymatous, *cells of basal angles regular, quadrate*, slightly transversely elongated or occasionally oblong, 13.9 μ wide by 9.2 μ long, varying from 12 to 17 μ in width and from 6.4 to 15 μ in length, toward the middle of the base *changing abruptly to long hexagonal*, almost vermicular, walls thin, usually thicker and firmer in the middle region, cells varying in width from 4.3 to 8.6 μ and in length from 28 to 58 μ, averaging 6.5 μ wide by 42.8 μ long, toward apical region gradually changing from hexagonal to rhomboidal, 8.8 μ wide by 24.6 μ long, ranging in width from 6.9 to 10.6 μ and in length from 17 to 32 μ, longest cells in the middle of the leaf; *in general the leaf cells very regular in all parts*, the alar quadrate cells sometimes extending as much as one third the length of the leaf; outer perichætial leaves broadly ovate, gradually acuminate, acumen half the length of the body, spreading, inner leaves ovate to oblong abruptly acuminate, acumen short, one fifth to one fourth the length of the body of the leaf, strict, all irregularly denticulate to dentate above the middle and costate to the middle, costa evident,

thin, occasionally simple, usually branched near the base or double.

Sporophyte small 0.5 to 1.5^{cm} long: seta purplish below, pale above, 140 to 18μ in diameter; central strand well differentiated, large, 35 to 58μ in diameter, composed of thirty-five to fifty rows of cells; cortex of two to three layers of cells 4.3 to 10.7μ in diameter, walls very strongly thickened, as are those of the ground tissue, the latter cells 12 to 17μ in diameter: capsule oblong to obovate, incurved from an erect base, asymmetric, gradually contracted to the seta, brownish purple throughout or paler on the concave side, usually more or less constricted under the mouth and the latter dilated in drying, 1.5 to 2^{mm} long, wall thin; cells of exothecium parenchymatous on the concave side, 25.7μ wide by 38.6μ long, ranging in width from 17 to 28μ and in length from 21 to 64μ, on the convex side more or less prosenchymatous, 20μ wide by 62μ long, ranging from 13 to 21.5μ wide and from 34 to 79μ long; walls of cells from 2 to 4μ, thicker on the concave side, three to six rows of isodiametric, hexagonal cells under the peristome 13 to 22μ; stomata few, eight to fourteen to the capsule, 25μ wide by 36μ long; peristome teeth linear-lanceolate, very slender pointed, transversely striate on the back below the middle, densely papillose above, hyaline border very narrow or none below, wider and serrate above, teeth yellow; endostome almost equaling the teeth, finely papillose in all parts, membrane narrow, one half the length of the segments, the latter lance-linear, perfect, entire, often not split along the keel, never gaping; cilia one or two, slender, nodulose, nearly equaling the segments; operculum equaling capsule in width, convex to high conic, obliquely apiculate or rostellate; annulus broad, of two to three rows of cells: spores light brown, surface minutely roughened, 8 to 12μ in diameter: calyptra equaling the capsule, split half its length.

HAB.: On shaded rocks, occasionally at base of trees. Type locality Lancaster, Pennsylvania.

Japan, North America: New Brunswick, Ontario, region of the Rocky mountains, New England, New York, District of

Columbia, New Jersey, Ohio, West Virginia, Wisconsin, Minnesota and Texas. Not rare.

This moss has in several instances been confused with *Hypnum reptile.* The likeness between the two forms however is only in general appearance and size. Once the leaves of the two are subjected to a microscopical examination no difficulty need be experienced in separating them, the leaves of *H. reptile* being long and gradually acuminate and strongly serrate in the upper half, generally distinctly falcate and secund. Between *A. adnatum* and *A. subtile* there are occasional forms which are puzzling in the absence of the sporophyte, but usually the size of the leaf and dimensions of the leaf cells are sufficient to separate them.

AMBLYSTEGIUM SERPENS (Hedw.) Br. and Sch. *Plate XI. fig. 6.*

SYNON.: *Hypnum serpens* Hedwig, Musc. Frond. 4: 45. *pl. 18.* 1797. Spec. Musc. 268. 1801.— Swartz, Musc. Frond. Suec. 65. 1799.— Bridel, Musc. Recent. 2²: 111. 1801. Spec. Musc. 2: 243. 1812. Mant. Musc. 183. 1819. Bry. Univ. 2: 642. 1827.— Smith, Fl. Brit. 1306. 1804.— Turner, Muscologiæ Hibernicæ Spicilegium 169. 1804.— Palisot de Beauvois, Prodr. 70. 1805.— Schultz, Prodromus Floræ Stugardiensis 322. 1806.— Weber and Mohr, Bot. Tasch. 300. 1807.— Wahlenberg, Fl. Lapp. 376. 1812. Fl. Carpat. 359. 1814.— Roehling, Deutschl. Fl. 3: 110. 1813.— Schwægrichen, Spec. Musc. Suppl. 1. 2: 260. 1816.— Martius, Cr. Erl. 15. 1817.— Hooker and Taylor, Muscologia Brittanica 94. 1818.— Hooker, Flora Scotica 2: 142. 1821.— Funck, Moost. 50. *pl. 45.* 1821.— Gray, Nat. Arr. Brit. Pl. 1: 754. 1821.— Huebener, Musc. Germ. 679. 1833.— De Notaris, Syl. Musc. Ital. 10. 1838.— Rabenhorst, Deutsch. Krypt. Fl. 2³: 292. 1848.— C. Mueller, Syn. Musc. Frond. 2: 411. 1851. Deutschl. Moos. 454. 1853.— Wilson, Bry. Brit. 362. 1855. Sullivant, Musc. and Hepat. U. S. 78. 1856.— Berkeley, Handb. Br. Moss. 96. 1863.— Hobkirk, Syn. of Brit. Mosses. 163. 1873.— Boulay, Musc. Fr. 79. 1884.— Lesquereux and James, Man. Moss. N. Amer. 373. 1884.

Hypnum spinulosum Hedwig, Spec. Musc. 269. *pl. 69. f. 5–10.* 1801.

Hypnum contextum Hedwig, Spec. Musc. 273. *pl. 72. f. 5–12.* 1801.

Amblystegium serpens Bruch and Schimper, Bry. Eur. Ambly. 9. *pl. 3.* 1853.— Schimper, Syn. (1st ed.) 591. 1860. (2d ed.) 709. 1876.— Milde, Bry. Siles. 323. 1869.— De Notaris, Epi. Bry. Ital. 153. 1869.— Hartmann, Skand. Fl. (10th ed.) 20. 1871.— Hobkirk, Syn. 212. 1884.— Lindberg, Musc. Scand. 1879.— Macoun and Kindberg, Cat. Can. Pl. 6: 218. 1892.— Husnot, Musc. Gall. 357. *pl. 102.* 1893.— Dixon and Jameson, Stud. Handb. 442. *pl. 56.* 1896. — Braithwaite, Brit. Moss. Fl. 3: 23. *pl. 89.* 1896.

Amblystegium serpens subsp. *schlotthaurri* Renauld and Cardot, Bot. Cent. 51: —. 1890.

EXSICCATI: *Hypnum serpens* Sulliv. and Lesq., Musc. Bor. Amer. (1st ed. 345. (2d ed.) 523.— Macoun, Can. Musc. 318 (Herb. Wis.).

Amblystegium serpens Austin, Musc. App. 373.

TYPE probably not in existence. The plant is supposed to have been described as early as 1696 by Ray.

Gametophyte bisexual, *small or of medium size*, usually densely cespitose, occasionally in loose mats, sometimes bright green, oftener dull yellowish green: *stems prostrate, generally much branched, slender, weak*, 100 to 150μ in diameter, 1 to 3^{cm} long; central strand well differentiated though small, 13 to 20μ in diameter, composed of eight to fifteen rows of cells; cortex of one or two layers of cells with walls moderately thickened, cells 6.5 to 13μ; cells of ground tissue 13 to 30μ in diameter; branches ascending or erect, flexuous with few branchlets .5 to 1.5^{cm} long: leaves ovate lanceolate to narrowly lanceolate, 320μ wide by 800μ long, varying in width from 260 to 360μ, and in length from 500μ to more than a millimeter, usually serrulate in upper two-thirds, flat or concave at base, *generally long acuminate*, occasionally subsecund, costate, *costa thin, weak, reaching to near the middle*, occasionally beyond (three-fifths the length of the leaf), or sometimes very short, occupying one sixth the leaf base at the line of insertion, 25 to 35μ wide, maximum width of leaf in basal sixth, upper two fifths a long slender acumen, leaf gradually widening below, when moist erect or open-spreading, in the dry condition either open or appressed; leaf cells parenchymatous below, those of the alar regions short rectangular to slightly transversely elongated, 17.4μ long by 15.3μ wide, varying from 13 to 18μ in width and from 15 to 19μ in length, in the costal region of base cells usually longer, the quadrate alar cells extending up to widest point of the leaf, there giving place to rectangular ones which in turn are soon succeeded by regularly hexagonal cells; those of middle lamina 11μ wide by 42μ long, ranging from 9 to 13μ wide and from 30 to 55μ long, the longest cells however usually being found in the long slender acumen, where they sometimes reach 60μ, varying in width from 11 to 13μ and in length from 40 to 60μ, averaging 12μ wide by 45μ long; perichætial leaves triangular lanceolate to oblong, erect, some-

times abruptly acuminate, acumen short, broadly costate to apex; outer triangular lanceolate, erect or slightly spreading; inner much larger, oblong, all costate, costa distinct, excurrent, forming a slender short acumen.

Sporophyte small to medium, 1^{cm} (rarely less) to 3.5^{cm} long: seta slender, 180 to 240μ in diameter, flexuous above, reddish brown at base, stramineous above; central strand well differentiated, 25 to 33μ in diameter, composed of thirty to forty rows of cells; cortex of three to five (usually four) layers of cells 6.5 to 13μ in diameter; cells of ground tissue 13 to 21.5μ: capsule 1.5 to 3^{mm} long, cylindrical or occasionally thickest at the mouth, tapering regularly from there to the seta, asymmetric, suberect to strongly incurved, collum one sixth the length of the sporangium, reddish or yellowish brown, frequently of two shades, becoming dull dirty brown with age, when empty frequently strongly incurved and constricted below the mouth; cells of the exothecium more or less prosenchymatous on the convex side, 23.5μ wide by 51.5μ long, varying from 13 to 37μ wide and from 30 to 82μ long, parenchymatous on the concave side, 25.5μ wide by 38.5μ long, ranging in width from 17 to 39μ and in length from 21 to 65μ, cell walls 3 to 4μ thick, three to five rows of cells under peristome isodiametric hexagonal, sometimes transversely elongated, 10.5 to 25μ in diameter; stomata eighteen to twenty-five, scattered, 42μ wide by 48μ long, ranging from 37 to 47μ wide and from 42 to 56μ long; peristome teeth lanceolate, dull brown below, pale above, marginal serrulate above, transversely striate on the back to beyond the middle, above this point faintly papillose; endostome equaling or slightly exceeding the teeth; membrane two thirds the length of the segments, the latter lanceolate, carinate, split along the keel between the articulations though scarcely gaping, papillose, as are also the one to three nodulose cilia which scarcely equal the segments; operculum apiculate from a highly convex or conic base; annulus broad of two or three rows of cells: spores finely papillose, light brown, 12 to 15μ in diameter: calyptra equaling capsule or shorter, split one half its length.

HAB.: On earth in moist places, at roots of trees and on decaying wood. Type locality England.

Found all over the world. Widely distributed in North America though less common than *A. varium.*

Amblystegium serpens stands as the type species around which the other members of the genus group themselves. It is a remarkably variable species though having few well marked varieties. It is most easily confounded with two of its close relatives *A. juratzkanum*, which by many is made a variety of it, and *A. varium*. *A. juratzkanum* is distinguished by having its leaves widely spreading and having its parts uniformly larger and its leaf cells longer at the base of the leaf. *A. varium* is generally a larger plant than A. *serpens*, has broader leaves, somewhat smaller cells throughout, and commonly has its leaves costate well towards the apex. Notwithstanding the differences in the well-marked forms, there are forms between them which will never cease to puzzle bryologists.

AMBLYSTEGIUM JURATZKANUM Schimp. *Plate XI. fig. 7.*

SYNON.: *Amblystegium juratzkanum* Schimper, Syn. (1st ed.) 693. 1860. 2d ed.) 710. 1876.—Milde, Bry. Siles. 327. 1869—Hartmann, Skand. Fl. (10th ed.) 19. 1871.—Husnot, Musc. Gall. 358. *pl. 102.* 1893. Flora Batavia, *pl. 939.*

Hypnum juratzkanum Boulay, Musc. Fr. 74. 1884.

Amblystegium serpens juratzkanum R. duBuysson, Étude du genre Amblys. 18. 1889.

Amblystegium juratzkæ Macoun & Kindberg, Cat. Can. Pl. 6:218. 1892.

Amblystegium juratzkæ Braithwaite, Brit. Moss Fl. 3: 25. *pl. 91.* 1896.

EXSICCATI: *Hypnum juratzkæ* Macoun, Can. Musc. 466.

TYPE in herb. Schimper.

Gametophyte bisexual, of medium size, loosely *cespitose*, bright green, becoming yellow below with age: stem slender, 2 to 4^{cm} long, 120 to 180 μ in diameter, cylindrical, prostrate, branched; central strand small and poorly developed or none, when present 8 to 17 μ in diameter, composed of three to ten rows of cells; cortex thin, not well differentiated, of one layer (rarely two) of cells 8.5 to 17 μ in diameter; cells of ground tissue 13 to 26 μ; primary branches few, prostrate; branchlets numerous, erect or ascending: *leaves linear lanceolate* to ovate lanceolate, *narrowly long acuminate, acumen equaling or exceeding the body of the leaf*, attaining greatest width in basal fifth, *serrulate to the base*, costate, costa

thin but distinct below, extending one half to two thirds the length of the leaf, one seventh to one fifth the entire width of leaf base at line of insertion, *widely spreading in both moist and dry conditions*, flat and straight or slightly concave at base, average leaves 300μ wide by 1050μ long, varying in width from 250 to 370μ and in length from 800 to 1200μ, leaves in smaller forms approaching those of *A. serpens* in form and size and in the larger forms reaching a length of 1400 to 1500 μ; leaf cells short oblong, rectangular, or rarely quadrate across the base, prosenchymatous above, hexagonal in the middle, *generally linear-hexagonal in the upper half of the acumen, longest cells usually found above the end of the costa*, alar cells 13.4μ wide by 24.4μ long, varying in width from 10 to 17μ and in length from 17 to 40μ, towards the middle 11.3μ wide by 52.4μ long, ranging in width from 8.5 to 13μ and in length from 40 to 70μ, and at the apex usually a little longer and narrower, 10.2μ wide by 63μ long, varying in width from 8.5 to 12.5μ and in length from 40 to 85μ; perichætial leaves triangular lanceolate or ovate lanceolate, pale, strict, short acuminate by the excurrent costa.

Sporophyte of medium size, 1.5 to 3^{cm} long: seta 180 to 300μ in diameter, flexuous above, red at base, yellow or pale brown above; cortex of two to four layers of cells 6.4 to 17μ in diameter; central strand well developed, 35 to 45μ in diameter, composed of fourteen to forty-five rows of cells; cells of ground tissue 13 to 35μ; capsule 2.5 to 3.5^{mm} long, slender, cylindrical, asymmetric, either moderately or strongly incurved from an erect base, slightly constricted under the mouth when dry, pale at maturity, usually light brown on the convex side and yellow on the concave side, frequently becoming darker colored when empty, collum slender, about one-fourth the length of the sporangium; exothecium cells mixed prosenchymatous and parenchymatous on the convex side, 34μ wide by 90μ long, varying in width from 17 to 51.5μ and in length from 47 to 110μ, parenchymatous on the concave side, 38.5μ wide by 64μ long, ranging from 21.5 to 56μ wide and from 30 to 90μ long, cell walls variable, 2 to 6μ thick, two to four rows of cells

under the peristome smaller, hexagonal or tranversely elongated, from 13 to 26µ long and from 18 to 36µ wide; stomata twenty-five to thirty-five to the capsule, scattered, 40µ wide by 50µ long; teeth of peristome lanceolate, pale yellow, long acuminate, margined, margin narrow at base becoming gradually wider above, reaching its greatest width about the middle, teeth serrulate above, transversely striate to the middle, here the striæ becoming irregular, some being oblique and some perpendicular, farther up the striæ replaced by papillæ which are scattered irregularly or arranged in parallel rows; endostome equaling the teeth or a little shorter, membrane one-half to three-fifths the length of the segments, the latter lanceolate, very slender pointed, perfect, carinate, open along the keel between the articulations but not gaping, membrane and segments finely and densely papillose as are the one to three stout cilia, the latter shorter than the segments; operculum convex to conic, apiculate; annulus of two rows of cells: spores light brown, finely punctulate, 15 to 18µ in diameter: calyptra two-thirds the length of the capsule, split half its length.

HAB.: On moist stones or earth. Type locality lower Austria.

Europe, Asia, North America: District of Columbia, Ontario, Wisconsin, Montana, Idaho, and British Columbia. Not common.

This species is very closely related to *A. serpens* by all its characters and small forms of it are difficult to distinguish from the latter. It is commonly of larger size throughout and has its leaf cells at base more commonly elongated. The general habit of the plant will usually aid in identifying it; the leaves are always widely spreading but not bent as is the case with *Campylium chrysophyllum*. From small forms of *A. riparium*, especially *A. riparium floridanum*, it may be found troublesome to separate it. The leaves of forms of *A. riparium* are entire, while those of *A. juratzkanum* are serrulate to the base.

AMBLYSTEGIUM COMPACTUM (C. Muell.) Aust. *Pl. XI. fig. 8.*

SYNON.: *Hypnum compactum* C. Mueller, Syn. Musc. Frond 2: 408. 1851. —Sullivant, Icon. Musc. 201. *pl. 123.* 1864.—Lesquereux & James, Man. Moss. N. Amer. 375. 1884.

Amblystegium serratum Bruch & Schimper, Bry. Eur. Ambly. 11. 1853.

Stereodon compactus Mitten, Jour. Linn. Soc. 8 : 43.

Amblystegium compactum Macoun & Kindberg, Cat. Can. Pl. 6 : 1892.

EXSICCATI: *Amblystegium compactum* Austin, Musc. App. 372; Macoun, Can. Musc. 324 (Herb. Wis.).

Hypnum serpens var. *compactum* Hooker in Drummond's Musc. Amer. 188.

TYPE in Herb. Hooker, Kew.

Gametophyte bisexual, of medium size, *usually in dense tufts from 0.5 to 2.5^{cm} deep*, sometimes forming loosely woven mats, pale green above, becoming yellow or rust colored below with age: stems slender 2 to 3^{cm} long, 120 to 190μ in diameter, rarely reaching 220μ, obscurely five angled, erect, ascending or occasionally almost prostrate, soft and flexible when moist, *fragile when dry, fasciculately branched*, tomentose radiculose to near the apex; central strand small, 3 to 6μ in diameter, of four to seven rows of cells, cells of ground tissue 13 to 32μ in diameter, cortex of one or two layers of cells 4.5 to 13.6μ, all tissues *having thin walls;* branches slender, short, 0.4 to 1^{cm} long, erect with tips generally inclined or curved, closely foliate; leaves lanceolate to ovate lanceolate, *more or less long and narrowly decurrent*, attaining greatest width in the basal fifth, usually near the line of insertion, 260μ wide by 780μ long, varying in width from 180 to 350μ and in length from 550 to 1000μ, in extremely large leaves reaching 500μ wide by 1200μ long, erect spreading crowded, not appressed when dry, straight or slightly falcate, gradually acuminate, acumen broad to tip, costate, costa generally *percurrent or nearly so*, rarely ceasing just above the middle, strong at base, sometimes thin and divided above or disappearing entirely for a short distance, one-fifth to one-sixth the leaf base at line of insertion, 30 to 50μ wide; dentate or rarely almost entire at the base, *teeth formed of a single or a double papilla over the transverse wall or by the protrusion of the adjoining corners* of the marginal cells above, the teeth being of the ordinary form, but frequently recurved; leaf cells parenchymatous across the base, somewhat abruptly and regularly prosenchymatous above, those of the alar regions (excluding the decurrent wing) quadrate to short rectangular, 8.6μ wide by 11.7μ long, ranging from 7 to 12.5μ wide and from 8.5 to 19μ long, those near the

costa being somewhat longer, the marginal row in the middle of the leaf rhomboidal with the marginal wall regularly thicker than (often twice as thick as) other walls of the same cell or the walls of other cells of the middle lamina, the latter oval to linear hexagonal, 6.5 μ wide by 47.6 μ long, varying in width from 4.7 to 8.6 μ and in length from 38 to 64.5 μ, at the apex of the leaf cells shorter and broader, sometimes irregular, 7.9 μ wide by 20.8 μ long, ranging from 5 to 8.6 μ wide and from 15 to 30 μ long; perichætial leaves oblong lanceolate, abruptly acuminate, acumen one-fifth the length of the body, serrulate in the upper third, entire below, costate, costa narrow, percurrent or excurrent.

Sporophyte small or medium, 1 to 3^{cm} long: seta slender, 130 to 160 μ in diameter, brown or purplish brown throughout, or paler above; central strand small, 17 to 22 μ in diameter, of six to eight rows of cells, cortex of one or two layers of cells 4 to 11 μ in diameter, beneath these the cells of the ground tissue abruptly larger, 15 to 30 μ: capsule 1.5 to 3^{mm} long, symmetric or asymmetric, erect or inclined, chestnut brown to brownish purple, constricted under the broad and slightly dilated mouth when dry; exothecium cells parenchymatous, generally regular, quadrate to short rectangular, walls very thick, 5 to 9 μ, cells 21 μ wide by 31.5 μ long, varying in width from 11 to 34 μ and in length from 21 to 60 μ, four to six rows of hexagonal transversely elongated cells under the peristome 24 μ wide by 14.3 μ long; stomata twelve to thirty to the capsule, 30 μ wide by 38.5 μ long; collum prominent, long, one-half the length of the sporangium; teeth of peristome lanceolate to linear lanceolate, yellow below, paler and narrowly margined above, densely and finely papillose on the back above, transversely striate in the lower half or occasional areas in lower half covered with papillæ arranged in transverse rows; endostome pale yellow, finely papillose, shorter than the teeth, membrane equaling the segments or nearly so, the latter lanceolate, carinate, open along the keel between the articulations, not gaping; cilia one or two, short and broad or obsolete; operculum high conic or apiculate from a convex base,

broad; annulus of one or two rows of cells: spores papillose, 15 to 21.5μ in diameter: calyptra small, one-third to one-half the length of the capsule, split one-half to three-fifths its length.

HAB.: On decayed wood, at the bases of trees in swamps or along streams. Type locality North America (Drummond).

North America: New Brunswick, Ontario, Lake Huron, Pennsylvania, New York, Wisconsin, Canadian Rocky mountains, Montana, Nevada, Utah, Colorado, California, and Washington. Widely distributed and not uncommon.

A well marked species, the habit of growth in more or less dense tufts being sufficient ordinarily to separate it from all of its relatives; further the strong and peculiar serration of its leaves mark it at once. After carefully examining all the material known to exist in America of *A. subcompactum* Kindb. and *A. dissitifolium* Kindb., I have been unable to separate them from *A. compactum*, though they differ from the typical form in some small degree.

AMBLYSTEGIUM VARIUM (Hedw.) Lindb. *Plate XI. fig. 10.*

SYNON.: *Leskea varia* Hedwig, Spec. Musc. 216. *pl. 53. f. 15–20.* 1801.—Bridel, Spec. Musc. 2: 71. 1812. Mant. Musc. 146. 1819.—Schwægrichen, Spec. Musc. Suppl. I. 2: 174. 1816.

Hypnum varium Palisot de Beauvois, Prodr. 72. 1805.

Hypnum orthocladon Bridel, Spec. Musc. 2: 241. 1812. Mant. Musc. 182. 1819. Bry. univ. 2: 537. 1827.—Schwægrichen, Spec. Musc. Suppl. 1. 2: 262. 1816.—Sullivant, Musc. and Hepat. of the U. S. 78. 1856. Icon. Musc. 199. *pl. 122.* 1864.—Lesquereux & James, Man. Moss. of N. Amer. 374. 1884.—Not of Palisot de Beauvois.

Hypnum debile Bridel, Spec. Musc. 2: 250. 1812.

Hypnum (Stereodon) varius Bridel, Bry. univ. 2: 652. 1827.

Hypnum serpens β. varium C. Mueller, Syn. Musc. Frond. 2: 412. 1851.

Amblystegium radicale Bruch & Schimper, Bry. Eur. Ambly. 10. *pl. 4.* 1853.—Schimper, Syn. Musc. Eur. (1st ed.) 592. 1860. (2d ed.) 711. 1876.—Milde, Bry. Siles. 324. 1869.—De Notaris, Epil. Bry. Ital. 154. 1869.—Hobkirk, Syn. (2d ed.) 213. 1884.

Hypnum radicale Wilson, Bry. Brit. 363. *pl. 25.* 1855.—Sullivant, Musc. and Hepat. of the U. S. 78. 1856.—Berkeley, Handb. Brit. Moss. 97. 1863.—Hobkirk, Syn. 164. 1873.—Boulay, Musc. Fr. 73. 1884.—Lesquereux & James, Man. Moss. of N. Amer. 373. 1884.—Not of Palisot de Beauvois.

Stereodon varius Mitten, Jour. Linn. Soc. 8: 43. 1864.

Amblystegium varium Lindberg, Musc. Scand. 32. 1872.—R. du Buysson Étud. gen. Ambly. 1883.—Macoun & Kindberg, Cat. Can. Pl. 6: 219. 1892.

— Husnot, Musc. Gall. 359. *pl. 103*. 1893.— Dixon & Jameson, Stud. Handb. 443. 1896.— Braithwaite, Brit. Moss Fl. 3 : 22. *pl. 88*. 1896.

Amblystegium varium var. *lesquereuxii* Renauld & Cardot, Flora Miquelonense 53. 1888.

Amblystegium orthocladon Macoun & Kindberg, Cat. Can. Pl. 6 : 219 1892.

Amblystegium porphyrrhizum Macoun & Kindberg, Cat. Can. Pl. 6 : 219. 1892.

EXSICCATI : *Hypnum radicale* Sullivant & Lesquereux, Musc. Bor. Amer. (1st ed.) 346. (2d ed.) 524.

Hypnum orthocladon Sullivant & Lesquereux, Musc. Bor. Amer. (1st ed.) 347. (2d ed.) 526.

Amblystegium serpens var. *radicale* Austin, Musc. App. 376.

Amblystegium serpens var. *orthocladon* Austin, Musc. App. 379.

Hypnum varium Macoun, Can. Musc. 320.

Hypnum porphyrrhizum Macoun, Can. Musc. 319 (Herb. Wis.).

TYPE in Herb. Hedwig.

Gametophyte bisexual, of *medium size or larger*, forming extensive loose or closely crowded tufts, tufts sometimes as much as 3^{cm} deep, variable in color, bright green, dull dark green or pale yellowish green: stems 150 to 325μ in diameter, 2 to 5^{cm} long, obscurely angled, prostrate, abundantly branched; central strand 8.5 to 35μ in diameter, of six to twenty-five rows of cells; cortex of two to four layers of cells 6 to 18μ in diameter; cells of ground tissue ranging from 17 to 30μ; branches stout or slender, 1 to 3^{cm} long, erect or ascending, flexuous, straight, or having the tips incurved, commonly crowded: leaves very variable in size and shape, lanceolate, *ovate lanceolate to broadly cordate ovate*, generally attaining greatest width in basal sixth, commonly gradually long acuminate, point usually slender, straight or slightly curved, margin entire or (in forms) denticulate above, flat or concave, costate, *costa extending to the apex or well into the base of the acumen*, one fifth to one fourth the leaf base at line of insertion; average leaves 500μ wide by 1200μ long, varying in width from 280 to 575μ and in length from 800 to 1400μ, both larger and smaller forms ocurring, spreading or somewhat appressed in both moist and dry conditions; leaf cells parenchymatous at base, prosenchy-

matous above, commonly regular, occasionally irregular, usually the one or two basal rows of cells somewhat larger than those above, 10 to 18μ wide by 25 to 40μ long, alar cells above these short oblong, quadrate or occasionally slightly transversely elongated, 10 to 15μ wide by 8.5 to 17μ long, in the costal region usually short rectangular, in the middle and apical regions cells hexagonal or the marginal row frequently short rhomboidal, middle leaf cells 9.5μ wide by 35μ long, varying in width from 8 to 13μ and in length from 25 to 48μ, apical cells 10.3μ wide by 34μ long, ranging from 9 to 12μ wide and from 25 to 44μ long; outer perichætial leaves triangular ovate, inner oblong, abruptly short acuminate, all strongly costate, costa excurrent, strict, or the outer spreading, serrulate or entire in the upper lamina.

Sporophyte small to large, 1 to 4^{cm} long: seta reddish at base, pale yellow above, or dark throughout, stout, 165 to 265μ in diameter; cortex of two to three layers of cells 6.4 to 14μ in diameter; central strand well differentiated, 20 to 36μ of eighteen to twenty-five rows of cells, cells of ground tissue 13 to 21.5 in diameter; capsule 1.5 to 6^{mm} long, cylindric, asymmetric, upright to horizontal, almost straight to strongly arcuate, more or less contracted under the mouth when dry, pale yellowish green at maturity, becoming chestnut brown with age; cells of exothecium parenchymatous on the concave side, 32μ wide by 51.4μ long, varying in width from 15 to 47μ and in length from 30 to 90μ, prosenchymatous on the convex side, 27μ wide by 70μ long, ranging from 13 to 42μ wide and from 35 to 120μ long, cell walls 3 to 5μ thick, two to six rows of cells under the peristome hexagonal isodiametric or transversely elongated, 18 to 35μ in diameter; stomata fifteen to thirty to the capsule, scattered, 32μ wide by 43μ long; collum variable, one fourth to one half the length of the sporangium; teeth of peristome cinnamon brown or yellow, paler above, lanceoate, acuminate, serrulate, margined, margin broadest in the middle region, transversely striate on the back in the lower three fifths, sparsely papillose above; endostome pale, finely and densely papillose

throughout, membrane one half the length of the segments; the latter lanceolate, carinate, open along the keel between the articulations, rarely gaping; cilia two to four, slender, equaling the segments, nodose to imperfectly appendiculate; operculum obliquely apiculate from a high convex or conic base, usually as broad as the capsule; annulus of two to three rows of cells: spores light brown, minutely papillose, 13 to 21μ in diameter: calyptra equaling the capsule or shorter, split half its length.

Hab.: On the ground, on decaying wood, at the bases of trees or occasionally on rocks, in moist or wet shady places. Type locality Lancaster, Pennsylvania.

Europe, North and tropical America: throughout southern Canada and the United States. Very common and widely distributed.

With the exception of *A. riparium*, the most variable of all species found in America; the smaller forms easily confused with *A. serpens*, while occasionally the more robust forms approach very nearly to *A. kochii* in the habit of growth and shape of leaf. Here as with *A. serpens*, while there is wide variation there are no forms of sufficient constancy to entitle them to varietal rank. The large form with erect straight branches commonly known as *A. orthocladon* perhaps is the most constant of all the forms, but I have not been able to call it anything more than a form.

AMBLYSTEGIUM IRRIGUUM (Wils.) Bruch & Schimp. *Plate XII. fig. 1.*

SYNON.: *Hypnum fluviatile.* Many authors prior to 1854. Not of Swartz.

Hypnum irriguum Wilson, Bryolog. Brit. 361. *pl. 25.* 1855.— Berkeley, Handb. Brit. Moss. 97. 1863.— Hobkirk, Syn. 164. 1873.— Boulay, Musc. Fr. 72. 1884.— Lesquereux & James, Man. Moss. N. Amer. 374. 1884.

Amblystegium irriguum Bruch & Schimper, Bry. Eur. Ambly. 11 (under the name *A. fluviatile*, *pl. 5.* 1853.— Schimper, Syn. Musc. Eur. (1st ed.) 594. 1860. (2d ed.) 712. 1876. — Milde, Bry. Siles. 326. 1869. — De Notaris, Epil. Bry. Ital. 152. 1869.— Hartmann, Skand. Fl. (10th ed.) 20. 1871. — Lindberg, Musc. Scand. 32. 1879.— Hobkirk, Syn. (2nd ed.) 213. 1884.— Macoun and Kindberg, Cat. Can. Pl. 6:220. 1892.— Husnot, Musc. Gall. 360. *pl. 103.* 1894.— Dixon & Jameson, Stud. Handb. 444. *pl. 56.* 1896. — Braithwaite, Brit. Moss Fl. 3:21. *pl. 88.* 1896.

Amblystegium fluviatile var. *irriguum* R. du Buysson, Ess. Anal. gen. Ambly. 1883.

EXSICCATI: *Amblystegium serpens* var. *irriguum* Austin, Musc. App. 375.

TYPE in Herb. Wilson.

Gametophyte bisexual, of medium size or larger, closely cespitose, *usually dark green*, sometimes light green or yellowish or brown: *stems rigid*, prostrate or ascending, irregularly subpinnately branched, 2^{cm} to 6^{cm} long, 200 to 350μ in diameter, cylindrical; central strand well differentiated, 25 to 40μ in diameter of sixteen to twenty-five rows of cells; cortex of three or four layers of cells, 6.5 to 13μ in diameter, walls strongly thickened, cells of ground tissue abruptly enlarged just within the cortex and increasing uniformly toward the center of the stem, reaching the greatest size near the central strand, 18 to 38.5μ in diameter; branches in the looser forms creeping or ascending, erect or ascending in the compactly growing patches, 0.5 to 3^{cm} long: leaves deltoid ovate, or ovate lanceolate, 400μ wide by 1000μ long, in large forms reaching 1500μ long, more or less cordate and decurrent, reaching greatest width in basal fifth, occasionally just above the line of insertion, acuminate, subserrulate, open-erect or spreading, *frequently subfalcate and subsecund*, costate to near the apex of the *usually long and slender acumen*, *costa strong*, *thick*, one-fifth to one-third the entire leaf base at line of insertion, 60 to 85μ wide, *tapering uniformly to the tip of the leaf*, *biconvex*, in the dry condition leaf points slightly incurved, otherwise as in the moist condition; leaf cells parenchymatous at base, prosenchymatous above, *usually one row of cells across the base of the leaf much enlarged*, 13 to 21.5μ wide by 30 to 55μ long, cells immediately above these *short-oblong*, 13μ wide by 21.5μ long, narrowing rapidly and becoming prosenchymatous at the greatest width of leaf, the cells in the alar regions (excluding the row of large cells at base) slightly transversely elongated, quadrate or short oblong, soon becoming oblong or rhomboidal above, 12 to 16μ wide by 9 to 20μ long, cells in the middle and upper parts of the leaf rhomboidal or hexagonal, the former 8.6μ wide by 31.5μ long, occasionally somewhat narrower, 6μ wide by 40μ long, the latter 9.5μ wide by 43μ long; perichætial

leaves ovate lanceolate to oblong lanceolate, erect, acuminate, costate, costa excurrent.

Sporophyte usually large, 1.5 to 4^{cm} long: seta stout, 200 to 280μ in diameter, dark purple below, reddish above; central strand equaling in diameter the largest cells of the ground tissue, 30μ, composed of ten to eighteen rows of cells; cortex of two to three layers of cells 8.6 to 12.8μ in diameter; cells of ground tissue varying from 18.5 to 30μ in diameter, the largest found about midway between the cortex and the central strand: capsule oblong or cylindrical, asymmetric, rarely almost symmetric, slightly inclined to strongly incurved, suberect to horizontal, generally strongly constricted under the mouth when dry; collum one-third the length of the sporangium; cells of exothecium mostly parenchymatous, more or less prosenchymatous on the convex side, cells on the convex side varying from 15 to 55μ wide and from 55 to 165μ long, averaging 30μ wide by 120μ long, cells of concave side 22 to 60μ in width and 43 to 128μ in length, averaging 38μ wide by 76μ long, walls 2 to 4μ thick, five to seven rows of cells under the mouth of the capsule isodiametric, or the three next the annulus slightly transversely elongated, 20 to 40μ in diameter; stomata thirty to forty to the capsule, 44μ wide by 58μ long, scattered; peristome teeth lanceolate, orange below, hyaline above, bordered, border narrow at base, becoming broader above, teeth entire or slightly serrulate above, transversely striate in the lower half or two thirds, papillose above; endostome shorter than the teeth, hyaline, papillose throughout, membrane three-fourths the length of the segments, the latter lanceolate to ovate-lanceolate, carinate, open along the keel between the articulations, not gaping, cilia two to four, equaling the segments or shorter, nodose; operculum apiculate from a highly convex or conic base; annulus broad, of two to three rows of cells: spores yellowish green, coarsely tuberculate, 15 to 21μ in diameter: calyptra two-thirds the length of the capsule, split half its length.

HAB.: Along the margins of brooks, ponds, lakes and other similar places on the ground and on stones. Type locality England.

Europe, Asia, Africa, and North America: New England, New York, New Jersey, Ohio, West Virginia, Wisconsin, Montana, Minnesota and Ontario. Not uncommon.

Long confused with *A. fluviatile*, from which plant it may be known by its long acuminate leaves, with a costa tapering gradually and uniformly from the base to the tip of the leaf, and by the leaf cells, which, above the basal row, are commonly uniformly smaller. This is especially true for the basal third of the leaf. The general habit of the two plants will aid in separating them, *A. irriguum* having a harsh and rigid appearance, while *A. fluviatile* is soft and pliable. *A. irriguum* may be distinguished from *Hypnum filicinum* by the broad triangular ovate leaves of the latter, having a distinctly serrate margin in the upper part and having the cells in the alar regions inflated.

AMBLYSTEGIUM IRRIGUUM SPINIFOLIUM Schimp. *Plate XII. fig. 1.*

SYNON.:[1] *Hypnum fallax* Bridel, Musc. Recent. 3^2: 66. *pl. 2. f. 1.* 1801. (fide Schimper, and many later authors.)

Hypnum filicinum var. *fallax* Hooker & Taylor, Muscologia Brittanica, 109.— Bridel, Bry. Univ. 2: 531. 1827.

Hypnum fluviatile C. Mueller, Syn. Musc. Frond. 2: 420. 1851.

Amblystegium irriguum var. *fallax* Schimper, Syn. Musc. Eur. (1st ed.) 594. 1860.

Amblystegium irriguum var. *spinifolium* Schimper, Syn. Musc. Eur. (2d ed.) 713. 1876.

Amblystegium fallax Lindberg, Musc. Scand. 32. 1879.—Braithwaite, Brit. Moss. Fl. 3: 19. *pl. 88.* 1896.

Amblystegium filicinum var. *fallax* Lindberg, Musc. Scand. 35. 1879.

Amblystegium fluviatile var. *irriguum*, forma *spinifolium* R. du Buysson, Ess. Anal. gen. Ambly. 1883.

Amblystegium vallis-clausæ var. *spinifolium* Husnot, Musc. Gall. 361. 1894.

TYPE in Herb. Bridel.

Gametophyte more robust than in the species; stems longer, 3 to 12^{cm}, more loosely branching; leaves generally *longer and narrower, with a long excurrent slender-pointed costa*, 900 to 1800μ long by 200 to 585μ wide; leaf cells at least in the upper portions of the leaf correspondingly elongated, 6 to 9μ wide by 40 to 70μ long.

[1] No attempt has been made to give a complete synonomy, owing to the confusion prior to the time of Schimper.

Sporophyte as in the species.

HAB.: In very wet places, either floating or on substratum kept constantly wet by spray or falling water. It appears to be of common occurrence in Europe, but is seldom met with in N. America. Type locality Europe.

Europe, Asia, Africa, and North America: New Jersey and Pennsylvania.

This form has been confused with the submerged form of *A. noterophilum* by most bryologists who have worked with American mosses. The latter is usually a much larger plant, having the body of the leaf ovate or broader, generally not acuminate except by the very strong long excurrent costa, which is twice as wide as that found in *A. irriguum spinifolium*; often appearing much wider, owing to the presence of a second layer of cells in the costal region of the lamina.

AMBLYSTEGIUM NOTEROPHILUM (Sulliv.) Holzinger. *Plate XII. fig. 3.*

SYNON.: *Hypnum noterophilum* Sullivant, Musc. and Hepat. of U. S. 78. 1856.

Hypnum fluviatile James, Proc. Academy Nat. Sciences of Philadelphia 1855: 447. 1855.

Hypnum irriguum var. *spinifolium* Lesquereux & James, Man. Moss. N. Amer. 374. 1884.—Macoun & Kindberg, Cat. Can. Pl. 6: 220. 1892.

Amblystegium noterophilum Holzinger, Bull. Geol. and Nat. Hist. Surv. Minn. 9: 293. Nov. 1895.

EXSICCATI: *Hypnum noterophilum* Sulliv. & Lesq., Musc. Bot. Amer. (1st ed.) 348.

Amblystegium serpens irriguum noterophilum Austin, Musc. App. 385.

TYPE in Herb. Sullivant, Cambridge.

Gametophyte bisexual, of medium or large size, varying from bright yellow green to a very dark dull green, rarely bronze in the new shoots of submerged plants, sometimes having a vitreous appearance, *harsh and rigid*, when growing out of water in close moderately thick tufts, in the water forming crowded floating masses: *stems rigid*, prostrate or ascending when not submerged, otherwise floating, profusely and irregularly branched, 2 to 15^{cm} long, 200 to 400μ in diameter, cylindrical; cortex of three to

four layers of incrassate cells 4 to 17 μ in diameter; central strand well differentiated, 30 to 45 μ in diameter, of twelve to twenty-one rows of cells; branches in terrestrial form ascending, 1 to 2.5^{cm} long, those of the submerged form 3 to 8^{cm} long bearing few short (1^{cm}) branchlets, in all cases densely leafy, the stems and branches of the submerged plants *at length naked or covered with the very stout excurrent costæ of the leaves*, due to the maceration of the leaf blade: leaves varying from *broadly triangular cordate ovate* in land form to long lanceolate in submerged form, *generally abruptly short acuminate by the excurrent costa*, straight or with the point moderately curved, in water form 550μ wide by 1350μ long, varying from 450 to 700μ wide and from 1050 to 1500μ long, extremely large plants having leaves 900μ wide by 2200μ long, in terrestrial plants the leaves proportionately wider, 500μ wide by 850μ long, rarely reaching 450μ wide by 600μ long, *strongly costate, costa commonly excurrent forming a very thick rather blunt cusp*, sometimes in the land form vanishing in the tip, one-sixth to one-third the leaf base at line of insertion, 65 to 225μ wide, plano-convex at base, double convex above to the tip, there sometimes becoming again flattened on the upper side; leaf blade *very commonly of two layers of cells in the basal sixth and along the costa well toward the tip*, margin *usually entire*, rarely slightly serrulate in the upper part of blade, greatest width of leaf attained in the basal sixth, open or erect spreading in land plants, slightly spreading or strict in submerged form; leaf cells parenchymatous at base, prosenchymatous in the middle and upper lamina, or mixed at the upper end of the blade, in the alar and apical regions in the extreme long and short forms cells essentially the same in size, those in the middle portion of the long leaves proportionately longer, in average leaves alar cells 14μ wide by 22μ long, varying from 12 to 17μ wide and from 19 to 23μ long, the middle leaf cells varying from 9 to 11μ wide and from 38 to 45μ long, averaging 10.5μ wide by 43.4μ long, these cells varying in the extreme forms from 9 by 18μ to 12 by 90μ, cells in upper lamina beside the costa 10μ wide by 28μ long, ranging from 9 to 11μ in width and from

25 to 32 μ long; perichætial leaves not essentially different from the others in shape and size, strongly costate, costa excurrent, cells *incrassate*, leaves all strict.

Sporophyte of medium size, 1.5 to 2.5^{cm} long, produced only on plants not submerged: seta stout, purple at base, paler almost yellow in upper third, 270 to 330 μ in diameter; cortex of three (occasionally four) layers of cells, these 6 to 15 μ in diameter; central strand 35 to 50 μ in diameter, composed of twenty to fifty rows of cells; cells of ground tissue 18 to 35 μ in diameter: capsule purple or dark chestnut brown, large, 2 to 4.5^{mm} long, cylindric or widening gradually from the base of the collum to the lid, asymmetric, incurved from an erect base, gradually cernuous, much shrunken in all parts and constricted under the mouth in drying; collum large, one-half to two-thirds the length of the sporangium; cells of the exothecium parenchymatous for the most part throughout, sometimes more or less prosenchymatous on the convex side, cells on the concave side 24 μ wide by 33 μ long, varying in width from 17 to 35 μ and in length from 21 to 50 μ, cells of convex side 18 μ wide by 55 μ long, ranging from 15 to 30 μ wide and from 25.5 to 77 μ long; cell walls 3 to 6 μ thick; cells under the peristome slightly smaller, two to four rows 8.5 to 30 μ long by 17 to 38.5 μ wide; stomata *very numerous*, *ninety to two hundred* to the capsule, *crowded in a comparatively narrow band and often clustered*, *two to seven adjoining*, commonly *as broad as long or broader*, average 37.5 μ wide by 36 μ long; teeth of peristome yellow at base yellowish brown above to the slender hyaline tip, lanceolate, acuminate, irregularly serrulate in upper third, narrowly bordered, transversely striate on the back to the middle or beyond, coarsely and irregularly papillose in upper third; endostome pale and faintly papillose throughout, shorter than the teeth, membrane two-thirds to three-fourths the length of the segments, the latter lanceolate, carinate, open along the keel between the articulations or with only occasional perforations along the keel, cilia one to three, slender, weak, nodose, shorter than the segments; operculum apiculate from a highly convex base: spores finely

papillose, 16 to 30 μ in diameter: calyptra one-half to three-fourths the length of the capsule, split one-third its length, falling before the spores are mature.

HAB.: In springs and at their margins (usually calcareous), and the streams running from them. Type locality Franklin county, Pennsylvania.

North America: Pennsylvania, New York, Illinois, Michigan, Wisconsin, Minnesota, Montana, Ontario. Local.

A plant that appears to be related to both *A. irriguum* and *A. fluviatile* with both of which it has been associated, especially the large floating form. Doubtless the absence of the sporophyte from most material and the exclusive (?) use of the water form for study have led to this confusion.

AMBLYSTEGIUM FLUVIATILE (Swartz) Br. & Sch. *Plate XII. fig. 2.*

SYNON.: *Hypnum fluviatile* Swartz, Musc. Frond. Suec. 63. 1799.—Hedwig, Spec. Musc. 277. *pl. 71. fig. 4.* 1801.—Palisot de Beauvois, Prodr. 1805. —Weber & Mohr, Bot. Tasch. 303. 1807.—Schwægrichen, Spec. Musc. Suppl. 1. 2 : 263. 1816.—Hartmann, Skand. Fl. (5th ed.) 333. 1849.—Wilson, Bry. Brit. 359. *pl. 55.* 1855.—Berkeley, Handb. Brit. Moss. 98. 1863.—Hobkirk, Syn. 164. 1873.—Lesquereux & James, Man. Moss. of N. Amer. 375. 1884.

Hypnum orthocladon Palisot de Beauvois, Prodr. 67. 1805.

Hypnum palustre fluviatile Wahtenberg, Fl. Suec. (2d ed.) 732. 1833.

Amblystegium fluviatile Bruch & Schimper, Bry. Eur. Ambly. Suppl. 1. 1. *pl. 1.* 1854.—Schimper, Syn. Musc. Eur. (1st ed.) 594. 1860. (2d ed.) 713. 1876.—Milde, Bry. Siles. 326. 1869.—Hartmann, Skand. Fl. (10th ed.) 20. 1871.— Lindberg, Musc. Skand. 32. 1879.—R. duBuysson, Ess. Anal. gen. Ambly. 12. 1883.—Hobkirk, Syn. (2d ed.) 213. 1884.—Macoun & Kindberg, Cat. Can. Pl. 6 : 220. 1892.—Husnot, Musc. Gall. 360. 1894.—Dixon & Jameson, Stud. Handb. 445. *pl. 56.* 1896.—Braithwaite, Brit. Moss Fl. 3 : 22. *pl. 88.* 1896.

Hypnum irriguum fluviatile Boulay, Musc. Fr. 73. 1884.

EXSICCATI: *Amblystegium fluviatile* Austin, Musc. App. 38.—Macoun, Can. Musc. 446.

TYPE in herb. Swartz, Stockholm.

Gametophyte bisexual, *soft and pliant*, of medium or large size, when not submerged on a solid substratum in dense thick tufts, when submerged, having a looser habit, sometimes considerably elongated and floating, varying in color from a dark dirty green to

light yellowish green, *usually with a vitreous or metallic luster:* stems prostrate when not submerged, ascending or floating when in the water, abundantly branched, sometimes sparingly so in water, *defoliate in the older portions* by the maceration of the leaves, 3 to 8^{cm} long, 180 to 210μ in diameter, scarcely angled; *central strand rudimentary or none*, when present of three to six rows of cells; cortex of two to four layers of cells 8.6 to 13μ in diameter, cells of ground tissue 13 to 20μ in diameter, abruptly larger than the cells of the cortex; branches simple, inclined or suberect, 1.5 to 4^{cm} long in terrestrial forms, longer in submerged plants, 3 to 7^{cm}, often with tips slightly hooked: leaves ovate, ovate lanceolate or oblong lanceolate, average leaves 650 to 700μ wide and 1500 to 1600μ long, concave, *very slightly or not at all acuminate*, point *usually blunt*, *entire*, strongly costate, costa plano-convex in the basal fourth of the leaf, double convex to almost cylindrical above, one-sixth to one-fourth the leaf base at the line of insertion, 85 to 120μ in width, tapering somewhat to the tip of the leaf, *here 45 to 60μ in width*, *flattening and disappearing abruptly within the point*, *strictly erect* or slightly spreading, occasionally subsecund, slightly incurved when dry, especially in terrestrial forms, not decurrent; leaf cells parenchymatous in lower half, at base *large*, 13 to 21.5μ wide by 30 to 70μ long, averaging across the base *16μ wide by 40μ long;* passing gradually into cells above varying from linear rectangular to linear rhomboidal or shorter, 10.5μ wide by 3 to 7μ long; these again passing gradually into cells regularly hexagonal, 10.5μ wide by 38μ long, cells at apex 15μ wide by 30μ long, alar cells rarely noticeably differentiated; perichætial leaves ovate or ovate-lanceolate, acute or sometimes short acuminate, costate to the erect apex, cells linear or nearly so, entire or denticulate at apex.

Sporophyte medium to large, 1.5 to 3.5^{cm} long: seta 180 to 240μ in diameter, purple at base, gradually passing to light brown or yellow above; central strand well developed, 25 to 45μ in diameter, of sixteen to thirty-five rows of cells; cortex of two to three layers of cells 6 to 12μ in diameter; cells of ground tissue abruptly larger than cortical cells, 13 to 20μ, larg-

est cells midway between cortex and central strand: capsule pale at maturity before dehiscence, usually brick red to chestnut brown when empty, 2 to 5^{mm} long, subcylindric or gradually widening to the mouth, incurved from an erect base to arcuate, more or less constricted below the mouth when dry; collum one-third to one-half the length of the sporangium; cells of exothecium parenchymatous on the concave side, 25μ wide by 47μ long, varying in width from 17 to 43μ, and in length from 21 to 77μ, longer on the convex side and more or less prosenchymatous, especially in the lower half of the sporangium, 25.5μ wide by 53.5μ long, ranging from 15 to 35μ wide and from 25 to 120μ long, five to seven rows of cells under the mouth isodiametric, 17 to 25.5μ in diameter, usually about two rows next the annulus transversely elongated, 8.5 to 15μ long by 17 to 30μ wide; cell walls 3 to 4μ thick; stomata numerous, *twenty-five to eighty* to the capsule, *38.5μ wide by 47μ long, scattered*; peristome teeth orange or reddish-brown below, margined, margin narrow at base widening above into the hyaline tip, serrulate in upper third, transversely striate on the back in the lower half, papillose above, occasionally having the striæ oblique or irregular in small areas near the middle; endostome pale, scarcely equaling the teeth, papillose throughout, membrane three-fourths the length of the segments, the latter lanceolate, carinate, split along the keel between the articulations, not gaping, cilia two or three, shorter than the segments, nodulose or subappendiculate; operculum conic and acute or apiculate from a highly convex base; annulus broad, of two to three rows of cells: spores finely tuberculate, 16 to 26μ; calyptra small, one-fourth to one-half the length of the capsule, split one-third its length.

HAB.: On rocks and earth in and along streams. Type locality Sweden.

Europe, and North America: New Brunswick, Newfoundland, Quebec, Ontario, New York, New Jersey, Ohio, Michigan, and Wisconsin.

The leaves of this species, usually not acuminate, with entire margin, broad blunt apex and strong costa vanishing in the tip, are generally suf-

ficient to enable one to distinguish it from its near relatives *A. irriguum* and *A. noterophilum*. Its larger leaf cells in the basal half will assist in separating it from the first, while the second generally has a much wider and generally excurrent costa, and two layers of cells in the lamina at the base and along the costa for half its length or more.

AMBLYSTEGIUM LESCURII (Sulliv.) Aust. *Plate XI. fig. 9.*

SYNON.: *Hypnum lescurii* Sullivant, Musc. and Hepat. of U. S. 79. 1856. Icon. Musc. 203. *pl. 124.* 1864.—Lesquereux & James, Man. Moss. of N. Amer. 376. 1884.

EXSICCATI: *Hypnum lescurii* Sulliv. & Lesq., Musc. Bor. Amer. (1st ed.) 350 (2d ed.) 529.

Amblystegium lescurii Austin, Musc. App. 371. 1870.

TYPE in herb. Sullivant, Harvard University.

Gametophyte bisexual, of medium size, loosely cespitose, *yellowish to dark green, ferruginous within the tufts with age:* stems prostrate, *generally defoliate in older parts*, profusely branched, *thick, rigid*, 160 to 210 μ in diameter, 2 to 6^{cm} long, obscurely angled; central strand small, 6 to 10 μ in diameter, composed of five to ten rows of cells; cortex of three to five layers of small incrassate cells, 6.5 to 13 μ in diameter, well differentiated from ground tissue, the cells of the latter *abruptly larger*, 18 to 26 μ in diameter; branches erect with very few branchlets, 1 to 3^{cm} long: *leaves ovate to very broadly ovate*, occasionally as broad as long, 360 μ wide by 750 μ long, reaching in some instances 1500 μ long, concave, abruptly *short* acuminate, *bordered, border of two layers of linear vermicular incrassate cells*, three to five cells wide, denticulate at apex, sometimes sparingly so to near the base, costate, costa thick, bi-convex in section, 40 to 55 μ wide, extending to the apex of the leaf, here becoming flattened and *blending with the thickened border*, when moist spreading in all directions, rarely subsecund, in the dry state the leaf tips more or less inflexed from the open-spreading bases; leaf cells parenchymatous, walls thick in all parts of the leaf, in the alar region usually a few short oval cells, excluding these alar cells long hexagonal or rhomboidal, 9 μ wide by 25 μ long, ranging in width from 6.5 to 13 μ and in length from 15 to 32 μ, in the middle border region cells 5.6 μ wide by 30.8 μ long, vary-

ing from 4.5 to 8.5 μ in width and from 24 to 39 μ in length, in the middle costal region cells much shorter and oval-hexagonal, 7.5 μ wide by 18 μ long, midway between border and costa the cells still shorter, at the apex the marginal cells oval or subrhomboidal, 9 μ wide by 17 μ long, varying from 8 to 10 μ wide and from 14 to 20 μ long; perichætial leaves ovate lanceolate to lanceolate, the outer gradually acuminate, all erect, strongly costate, costa long excurrent.

Sporophyte medium, 1 to 3^{cm} long: seta stout, 250 to 300 μ in diameter, dark purple below, yellow above; central strand well developed, 30 to 38 μ in diameter, of thirty to forty rows of cells, walls of cells strongly thickened for this tissue; cortex of three to four layers of cells, 4 to 13 μ, passing gradually into ground tissue; cells of this tissue ranging from 13 to 23 μ: capsule oblong, unsymmetric, cernuous, with short collum, becomimg dark brick red with age, not constricted under the mouth when dry or only moderately so; cells of exothecium parenchymatous on concave side, 23 μ wide by 32 μ long, ranging in width from 20 to 26 μ, and in length from 17 to 47 μ, prosenchymatous on convex side, 20 μ wide by 40 μ long, varying from 13 to 23 μ wide and from 30 to 65 μ long; cell walls 2 to 3 μ thick; three to five rows of isodiametric, quadrate or hexagonal cells under the mouth, 15 to 22 μ in diameter, walls 4 μ thick; stomata ten to twenty-five to the capsule, 30.5 μ wide by 34.5 μ long, scattered; peristome teeth lanceolate, golden yellow with a broad paler margin, serrate in the upper half, transversely striate on the back to near the middle, above this point dotted with scattered papillæ among the striæ, the latter soon being replaced above by densely crowded ciliate papillæ; endostome pale yellow, equaling the teeth; membrane two-thirds the length of the segments, the latter lanceolate, carinate, split, but not widely open along the keel between the articulations, finely papillose, cilia one to three, stout, shorter than the segments, nodulose; operculum apiculate from a convex or conic base; annulus broad, of two to three rows of cells: calyptra equaling capsule, split one-third its length.

HAB.: On wet rocks, usually in mountain streams. Type locality Tallulah Falls, Georgia.

North America: Georgia, Virginia, West Virginia, Pennsylvania, New York, New Jersey, Maine. Rare or local.

The most distinctly characterized of all our Amblystegia. No difficulty need be experienced in separating it from other species if one of its leaves is at hand. The leaf border is evident under moderate magnification.

AMBLYSTEGIUM RIPARIUM (Hedw.) Br. & Sch. *Plate XIII. fig. 1.*

SYNON.: *Hypnum riparium* Hedwig, Musc. Frond. 4:7 *pl. 3.* 1797. Spec. Musc. 241. 1801.—Abbot, Flora Bedfordiensis 250. 1798.—Hull, British Flora 2:273. 1799.—Swartz, Musc. Suec. 1799.—Bridel, Musc. Recent. 3:176. 1801. Spec. Musc. 2:112. 1812. Mant. Musc. 157. 1819. Bry. Univ. 2:412. 1827.—Smith, Fl. Brit. 1292. 1804. Eng. Bot. *pl. 2060.*—Turner Musc. Hib. 152. 1804.—Palisot de Beauvois, Prodr. 69. 1805.—Schultz, Fl. Starg. 324. 1806.—Weber & Mohr, Bot. Tasch. 331. 1807.—Voit, Muscorum Herbipolitano 111. 1812.—Schwægrichen, Spec. Musc. Suppl. 1. 2:194. 1816.—Hooker & Taylor, Musc. Brit. 92. 1818.—Hooker Fl. Scot. 2:141. 1820.—Funck, Moost. 56. *pl. 37.* 1821.—Gray. Nat. Arr. Brit. Pl. 1:752. 1821.—Huebener, Musc. Germ. 619. 1833.—DeNotaris, Syllab. 4. 1838.—Rabenhorst, Deutschl. Kr. Fl. 2^3:293. 1848.—C. Mueller, Syn. Musc. Frond. 2:321. 1851. Deutchl. Moos. 427. 1853.—Wilson Bry. Brit. 364. 1855.—Sullivant, Musc. and Hepat. U. S. 79. 1856.—Berkeley, Handb. Brit. Moss. 98. 1863.—Hobkirk, Syn. 164. 1873.—Boulay, Musc. Fr. 76. 1884.—Lesquereux & James, Man. Moss. N. Amer. 376. 1884.—Dixon & Jameson, Stud. Handb. 452. 1896.

Amblysteginm riparium Bruch & Schimper, Bry. Eur. Ambly. 14. *pl. 8.* 1853.—Schimper, Syn. Musc. Eur. (1st ed.) 597. 1860. (2d ed.) 717. 1876.—Milde, Bry. Siles. 328. 1869.—De Notaris, Epil. Bry. Ital. 146. 1869.—Hartmann, Skand. Fl. (10th ed.) 19. 1871.—R. du Buysson, Ess. anal. gen. Ambly. 1883.—Hobkirk, Syn. (2d ed.) 213. 1884.—Macoun & Kindberg. Cat. Can. Pl. 6:221. 1892.—Husnot, Musc. Gall. 363. *pl. 104.* 1893.—Braithwaite, Brit. Moss. Fl. 3:29. *pl. 89.* 1896.

Stereodon riparium Mitten, Jour. Linn Soc. 8:43. 1864.

EXSICCATI: *Hypnum riparium* Sulliv. & Lesq., Musc. Bor. Amer. (1st ed.) 349. (2d ed.) 527.—Macoun, Can. Musc. 325.

TYPE probably not in existence. The plant was known to botanical writers prior to the time of Dillenius, probably early in the eighteenth century.

Gametophyte bisexual, medium *to very large*, *in extensive loose tufts*, bright green to yellowish green, occasionally of a decided yellow or bronze: stems *long*, *flaccid*, *prostrate* or floating, spar-

ingly branched, 5 to 20^{cm} long, 250 to 400μ in diameter, cylindrical; central strand well differentiated though small, 20 to 27μ in diameter, of ten to fifteen rows of cells; cortex of two to three layers of cells, usually not well differentiated, cells 8 to 22μ in diameter, those of the ground tissue 17 to 40μ; primary branches few, 2 to 8^{cm} long, prostrate, branchlets short, 1 to 3^{cm}, prostrate: leaves ovate lanceolate to linear lanceolate, long acuminate, terminating in a slender, straight, or curved point, 650μ wide by 2200μ long, ranging in width from 450 to 700μ and in length from 1700 to 2400μ, attaining greatest width in the basal fifth, many ranked, commonly complanate, occasionally equally spreading or subsecund, rarely erect, ordinarily more or less widely spreading, frequently folded or twisted when dry, costate, costa thin, extending through the lower half to three-fourths of the leaf, one-sixth to one-fifth its base at the line of insertion, 50 to 75μ wide, margin ordinarily *very entire*, rarely subserrulate; leaf cells parenchymatous across the base, soon becoming prosenchymatous above, the basal cells quadrate to oblong, the one or two marginal rows narrower and longer, 16μ wide by 36.6μ long, ranging from 13 to 20μ in width and from 20 to 50μ in length; cell walls strongly thickened and *sparsely* pitted, in all parts of the leaf above the basal eighth the cells *long hexagonal to linear*, in the middle region 8.5μ wide by 95μ long, varying in width from 7.8 to 9μ and in length from 85 to 100μ, frequently vermicular, cells of apical region shorter, 9.3μ wide by 34μ long, ranging from 8.8 to 10μ in width and from 28 to 38μ in length; outer perichætial leaves triangular-ovate, spreading from the middle, inner oblong, erect, all abruptly short acuminate and costate to the base of the acumen or nearly so, coarsely and irregularly serrate above or entire.

Sporophyte medium, 1 to 3^{cm} long: seta purple at base, light brown or yellow above, or uniformly pale brown throughout, 170 to 260μ in diameter, cortex of two to three layers of cells, 6.5 to 15μ in diameter; central strand well differentiated, 30 to 36.5μ in diameter, composed of thirty to forty-five rows of cells; cells of ground tissue 9 to 26μ in diameter: capsule short, oval,

1 to 2^{mm} long, pale yellowish green at maturity, sometimes of two colors, pale on the concave side and brown above, becoming a uniform light brown or dark chestnut brown, unsymmetric, from slightly inclined to horizontal, strongly incurved, constricted under the mouth when dry; collum one-fourth to one-third the length of the sporangium; cells of exothecium parenchymatous throughout or more or less prosenchymatous on the convex side, cells on the concave side 43μ wide by 53.5μ long, ranging from 21.5 to 60μ in width and from 30 to 77μ in length, those on the convex side 34.5μ wide by 82.5μ long, ranging in width from 21 to 43μ and in length from 60 to 120μ, cells under the peristome but slightly different, sometimes one or two rows a little smaller and transversely elongated, 17 to 21.5μ long by 17 to 26μ wide; cell walls 2 to 3μ thick; stomata twenty-five to thirty-five to the capsule, scattered, 43μ wide by 52μ long; peristome teeth light brown at base, paler above, hyaline at the points, narrowly margined, serrate in the upper third, transversely striate on the back in the basal three-fifths, with occasional areas near the middle with striæ running obliquely or longitudinally, papillose above, papillæ large; endostome shorter than the teeth, hyaline, papillose throughout, membrane one-half to two-thirds the length of the segments, the latter carinate, frequently not open along the keel except in the upper third, never gaping, cilia one to four, slender, nodose or appendiculate, equaling the segments; operculum rostellate or apiculate from a depressed convex to conic base; annulus broad, of two to three rows of cells: spores finely tuberculate, 13 to 21μ in diameter: calyptra equalling the capsule, split half its length or less.

HAB.: In wet localities, either in stagnant or slow running water, or on the ground, logs, boards, etc.

Type locality England, Thames river. Common and variable everywhere.

This species is probably the most variable of all our Amblystegia though in general habit it is comparatively constant. It is sometimes confused with *Hypnum* (*Campylium*) *polygamum*. The latter plant generally has a different habit; its stems more or less upright, with leaves equally spreading in all directions from near the base.

AMBLYSTEGIUM RIPARIUM FLORIDANUM Ren. & Card. *Plate XIII. fig. 2.*

SYNON.: *Amblystegium riparium* var. *floridanum* Renauld & Cardot, Botanical Gazette 14 : 98. 1889.

Amblystegium floridanum Renauld & Cardot, Musci. Americæ Septentrionalis 58. 1893.

TYPE in herb. Cardot, Stenay, France.

Gametophyte small: stems 1 to 2^{cm} long, sparsely branched: leaves *linear to lanceolate*, 50 to 330μ wide by 800 to 1200μ long; leaf cells about as in the species in all parts.

Sporophyte small, 1^{cm} long; capsule 1 to 1.5^{mm} long.

Hab.: On decaying wood in moist or wet places. Type locality Florida and Louisiana.

North America: Gulf and south Atlanlic states.

Has the general habit and appearance of the species throughout. May be known by its very small size.

AMBLYSTEGIUM RIPARIUM ABBREVIATUM Br. & Sch.

SYNON.: *Amblystegium riparium abbreviatum* Bruch & Schimper, Bry. Eur. Ambly. 14. *pl. 9. f. β. 1* and *2.* 1853.—Schimper, Syn. Musc. Eur. (1st ed.) 598. 1860 (2d ed.) 718. 1876.—De Notaris, Epil. Bry. Ital. 147. 1869.—Husnot, Musc. Gall. 363. 1894.—Braithwaite, Brit. Moss. Fl. 3 : 30. 1896.

Hypnun riparium var. *abbreviatum* Lesquereux & James, Man. Moss. N. Amer. 377.

Gametophyte with stems and branches *short*, the former *1 to 3^{cm} long*, the latter *1^{cm} long:* leaves as in the species except a little smaller in size.

Sporophyte as in medium forms of the species.

Type locality, Europe.—Europe and North America.

Probably this and the preceding variety will have to be omitted when more abundant material can be obtained for study. Found occasionally with the species.

AMBLYSTEGIUM RIPARIUM FLACCIDUM (L. & J.) R. & C.

SYNON.: *Hypnum riparium* var. *flaccidum* Lesquereux & James Man. Moss. N. Amer. 377.

Amblystegium riparium var. *flaccidum* Renauld & Cardot, Musc. Amer. Sept. 58. 1893.

TYPE in herb. James, Harvard University.

Gametophyte very much attenuated: stems long, *filiform*, 10 to 40^{cm} long, sparingly branched; branches correspondingly long: leaves slender, *remote*.

Sporophyte usually much larger than in other forms, 3 to 6^{cm} or more long, not abundant.

HAB.: Growing in the water, generally in shaded places. A common form in N. America with the species.

AMBLYSTEGUM RIPARIUM FLUITANS (L. & J.) R. & C.

SYNON.: *Hypnum riparium* var. *fluitans* Lesquereux & James, Man. Moss. N. Amer. 377.

Amblystegium riparium var. *fluitans* Renauld & Cardot, Musc. Amer. Sept. 58. 1893.

Gametophyte large: stems and branches long, 10 to 20^{cm}, dirty green or yellow: leaves *large, 800 μ wide by 3200 μ long*, sometimes more than 4000 μ in length and of proportionate width.

Sporophyte rarely produced, not seen by me.

HAB.: Floating in shallow water at margins of streams and from logs, stumps, etc., in the water.

With the species. Not uncommon.

AMBLYSTEGIUM RIPARIUM LONGIFOLIUM (Schultz) Sch. & Buys.

SYNON.: *Hypnum longifolium* Schultz, Fl. Starg. 335. 1806.—Bridel, Spec. Musc. 2: 114. 1812. Mant. Musc. 158. 1819.

Hypnum riparium longifolium Bridel, Bry. Univ. 2: 414. 1827.

Amblystegium riparium var. *longifolium* Schimper, Syn. Musc. (1st ed.) 598. 1860. (2d ed.) 718. 1876.— Braithwaite, Brit. Moss. Fl. 3: 29.

Gametophyte large, yellowish green to bright yellow or bronze: stems moderately elongated, 3 to 8^{cm} long: leaves large, 600 to 700 μ wide by 3500 to 4200 μ long, acuminate, acumen very slender.

Sporophyte unknown to me.

HAB.: Europe, and North America: Vancouver and Washington.

The forms here given as varieties are thought to be the most constant ones and those about which the well nigh numberless others may be satisfactorily grouped.

AMBLYSTEGIUM KOCHII Br. & Sch. *Plate XII. fig. 5.*

SYNON.: *Amblystegium kochii* Bruch & Schimper, Bry. Eur. Ambly. 13. *pl. 6.* 1853.—Schimper, Syn. Musc. Eur. (1st ed.) 596. 1860. (2d ed.) 716. 1876.—Milde, Bry. Siles. 327. 1869.—Hartmann, Skand. Fl. (10th ed.) 19. 1871.—Husnot, Musc. Gall. 362, *pl. 104.* 1894.—Dixon & Jameson, Stud. Handb. 449. *pl. 56.* 1896.

Amblystegium curvipes Guembel, Bry. Eur. Ambly. 14. *pl. 7.* 1853.—Schimper, Syn. Musc. Eur. (1st ed.) 597. 1860. (2d ed.) 717. 1876.—Macoum & Kindberg, Cat. Can. Pl. 6 : 220. 1892.

Amblystegium ambiguum De Notaris, Epil. Bry. Ital. 144. 1869.

Amblystegium trichopodium var. *kochii* Lindberg, Acta Soc. Sci. Fenn. 10 : 275. 1872.—Braithwaite, Brit. Moss Fl. 3 : 30. *pl. 89.* 1896.

Amblystegium riparium var. *kochii* R. duBuysson, Ess. anal. gen. Ambly. 20. 1883.—Boulay, Musc. Fr. 77. 1884.

TYPE in Herb. Guembel, Berlin.

Gametophyte bisexual, of medium or large size, forming wide loose tufts, ordinarily pale, light green, to yellow : stems prostrate, 2 to 4^{cm} long, flattened or obscurely angled, 180 to 300μ in diameter, cortex well differentiated, of two to three layers of cells, these 6 to 13μ in diameter; central strand 30 to 35μ, of ten to fifteen rows of cells; cells of ground tissue 13 to 35μ in diameter ; branches prostrate, ascending or sometimes erect, 1 to 3^{cm} long : leaves *long acuminate from a broadly-ovate or ovate base,* acumen slender, two-thirds the length of the body, sometimes equaling it or even longer; leaf attaining greatest width in the basal eighth, varying from serrulate in the middle leaf region to distinctly serrate throughout, costate, costa distinct, extending through two-thirds to three-fourths the length of the leaf, ceasing in the base of the acumen, one-sixth to one-fifth the leaf base at the line of insertion, 60 to 85μ wide ; many ranked, *commonly widely spreading from the base in all directions*, scarcely different in the dry condition, more or less crowded, 530μ wide by 1400μ long, ranging in width from 350 to 640μ and in length from 1100 to 1500μ; leaf cells parenchymatous in basal eighth, prosenchymatous above, cells of alar region oblong to short oblong, occasionally quadrate, 15.7μ wide by 25.8μ long, varying in width from 11 to 17μ and in length from 18 to 28μ, the marginal two to three

rows narrower than those toward the costa, the latter 17 to 26μ wide by 40 to 60μ long, walls moderately thickened, above the cells pass rapidly through hexagonal or rhomboidal along the margin to almost linear hexagonal at the middle region, 10.4μ wide by 54μ long, varying in width from 9 to 11μ and in length from 45 to 60μ, rarely reaching 100μ, in the apical region, cells essentially like those of the middle region, 10.7μ wide by 56μ long, varying in width from 9 to 11μ and in length from 40 to 68μ; perichætial leaves ovate lanceolate to oblong lanceolate, the outer spreading, the inner erect, all costate, serrate above.

Sporophyte medium to large: seta 2 to 4.5^{cm} long, 225 to 325μ in diameter, cortex of three to four layers of incrassate cells, 8.5 to 17μ in diameter: central strand large, 43 to 52μ in diameter, of thirty to forty-five rows of cells; cells of ground tissue 9 to 33μ in diameter: capsule oval to short cylindric, asymmetric, moderately incurved from an erect base to horizontal or cernuous, pale throughout or darker on the convex side, constricted under the mouth when dry; collum small, one-sixth to one fifth the sporangium; cells of exothecium mostly parenchymatous throughout, occasionally prosenchymatous on the convex side, cells on the concave side 38.5μ wide by 51.5μ long, ranging from 26 to 64.5μ wide and from 35 to 85μ long, those of the convex side 33μ wide by 105μ long, varying in width from 18 to 47μ and in length from 55 to 180μ; cell walls 2 to 3μ thick, three to six rows of cells under the peristome smaller, hexagonal, isodiametric or occasionally transversely elongated, 10.7 to 40μ long by 17 to 34μ wide; stomata thirty-five to forty-five to the capsule, 42μ wide by 57μ long, scattered; teeth of peristome linear lanceolate, yellowish brown at base, margined, margin narrow below, abruptly wider at the middle, passing into the hyaline tip, upper half of teeth serrate, transversely striate on the back in the basal half, coarsely papillose above; endostome equaling the teeth, yellow, densely and coarsely papillose throughout, membrane not equaling the segments; the latter narrowly lanceolate, strongly carinate, open along the keel between the articulations, cilia two, occasionally

one or three, nodose to imperfectly appendiculate, usually shorter than the segments, occasionally equaling them; operculum as wide as the capsule, blunt pointed from a convex base: spores finely papillose, 16μ to 23μ in diameter: calyptra equaling the capsule or nearly so, split half its length.

HAB.: In moist shady places on earth. Type locality Germany.

Europe, Asia, North America: District of Columbia, Minnesota(?), Kansas. Not common.

Closely related to *A. riparium*, the smaller forms of which it resembles. It may generally be known from these by the long slender acumen and serrate margin of its leaves. It may be confused with large forms of *A. varium*. The leaves of the latter are commonly shorter pointed and have the leaf cells smaller throughout and especially shorter at the base.

AMBLYSTEGIUM VACILLANS (Sulliv.). *Plate XII. fig. 4.*

SYNON.: *Amblystegium vacillans* Sullivant, Mss. 1870. Icon. Musc. Suppl. 96. *pl. 72.* 1874. Macoun & Kindberg, Cat. Can. Pl. 6:222. 1892.
Hypnum vacillans Lesquereux & James, Man. Moss. N. Amer. 377. 1884.

Gametophyte bisexual, medium to large, loosely cespitose, pale yellowish green: stems prostrate or floating, sparingly branched, 2 to 6^{cm} long, 175 to 385μ in diameter; central strand poorly differentiated, 20 to 30μ in diameter, composed of six to ten rows of large cells, 6.5 to 12μ in diameter; cortex of three to five layers of cells 6 to 17μ, those of the ground tissue abruptly larger, 17 to 35μ; branches short, 1 to 2^{cm} long: leaves lanceolate to oblong lanceolate, attaining greatest width in basal third, acuminate or acute, *tip broad and blunt*, slender, *entire*, costate, costa distinct, extending three-fourths to four-fifths the length of the leaf, about one-seventh the leaf base at line of insertion, 35 to 47μ wide; many ranked, complanate or equally spreading on the branches, open erect, in small plants 400μ wide by 1340μ long, ranging from 330 to 450μ wide and from 1050 to 1550μ long, in larger plants reaching 685μ wide by 2150μ long; leaf cells parenchymatous at base, leaf ordinarily separating from the stem leaving at the basal angle a small group of quadrate or

short oblong cells, 13μ wide by 22μ long, varying in width from 10 to 15μ and in length from 18 to 25μ, sometimes below these is a row of slightly inflated and elongated cells across the base 20 to 26μ wide by 40 to 50μ long, the cells in the one or two marginal rows at the base frequently much elongated, reaching 100μ, in all parts of the leaf above the basal eighth cells prosenchymatous, in the middle region linear, 8.3μ wide by 49μ long, ranging in width from 6.5 to 9μ, and in length from 40 to 56μ, *in the apical region shorter, slightly wider and more or less irregular, oval, hexagonal or rhomboidal*, 8.6μ wide by 23.5μ long; outer perichætial leaves triangular, reflexed from the middle, the inner lanceolate or oblong, erect, all acuminate, costate, costa vanishing in the acumen, entire.

Sporophyte medium, 1.5 to 25^{cm} long: seta brown below, paler above, slender; capsule light brown when old, 1.5 to 2^{mm} long, cylindrical, oval or obovate, asymmetric or rarely almost symmetric, from erect to incurved, not constricted under the mouth when dry; collum one-sixth to one fourth the length of the sporangium; cells of the exothecium irregular, mostly parenchymatous throughout, somewhat prosenchymatous on the convex side, cells on the concave side 32μ wide by 50μ long, varying in width from 15 to 47μ and in length from 21.5 to 77μ, on the convex side 28μ wide by 62μ long ranging from 13 to 38.5μ wide and from 25 to86μ long; three to six rows of cells under the mouth transversely elongated, hexagonal, 21.5 to 43μ wide by 8.6 to 25.8μ long; cells walls 3 to 4μ thick; stomata twenty to thirty to the capsule, scattered, 32μ wide by 38μ long; peristome teeth narrowly lanceolate, brown below, pale above, narrowly margined, transversely striate on the back below the middle, papillose above, serrulate above; endostome pale, papillose throughout, faintly so on the membrane, this only one half the length of the segments, segments linear lanceolate, carinate, open along the keel between the articulations, cilia one or two, short, one half the length of the segments, nodulose; operculum conic; annulus narrow, of one row of cells: spores finely puncticulate, 13 to 18μ in diameter: calyptra not seen.

HAB.: That of *A. riparium*. Type locality White Mountains, New Hampshire.

North America: New Hampshire, New Jersey, Ontario. Rare.

Closely related to *A. riparium*. It may be known by the irregular and usually very short cells in apical region of the leaf and the wide blunt tips of the branch leaves.

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EXPLANATION OF PLATES XI–XIII.

The leaf outlines were magnified 85 diameters in the original drawing; the cells from the three leaf regions 580 diameters; *fig. 3l (pl. XII)*, 340 diameters; *fig. 3f* and *3f.'*, and *3g* of the same plate 160 diameters; and *3h* 10 diameters. All originals reduced one half.

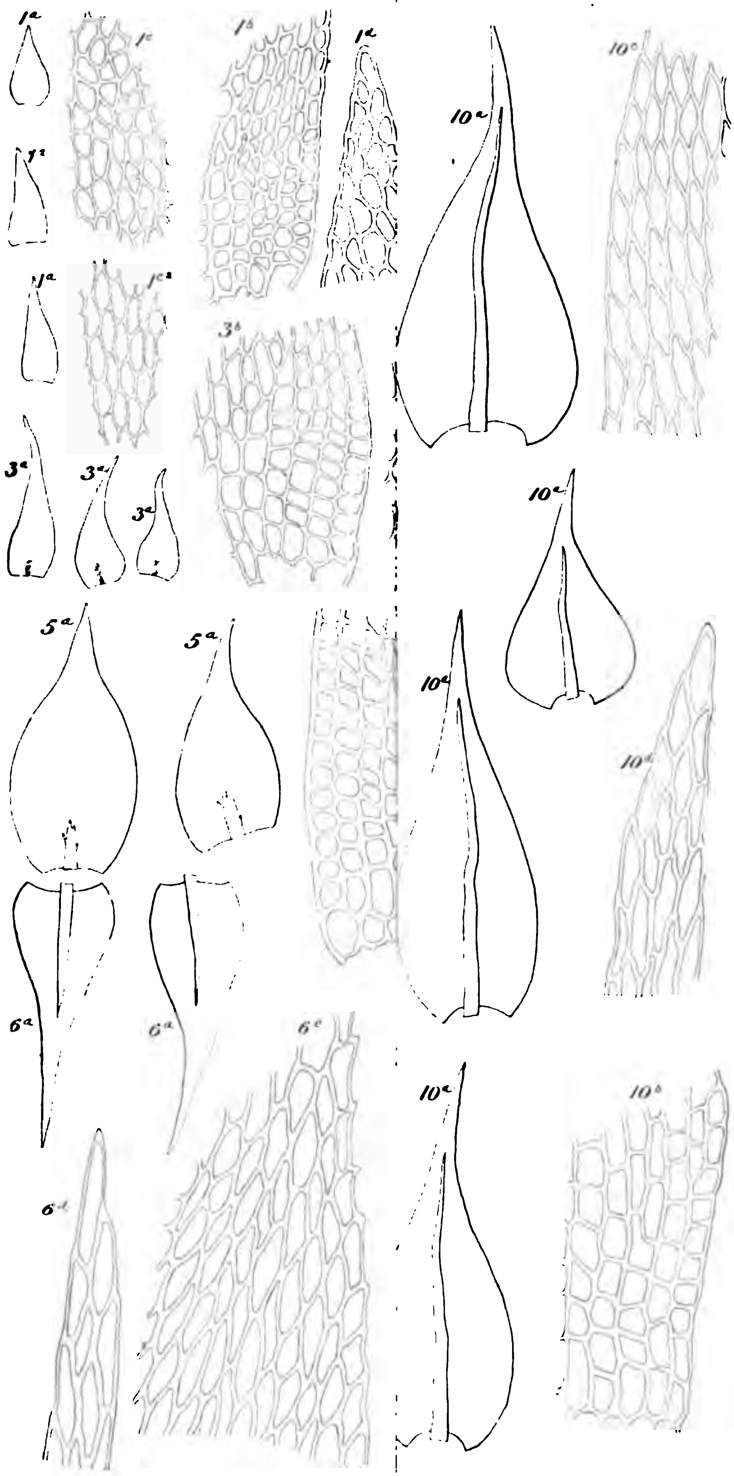
PLATE XI.

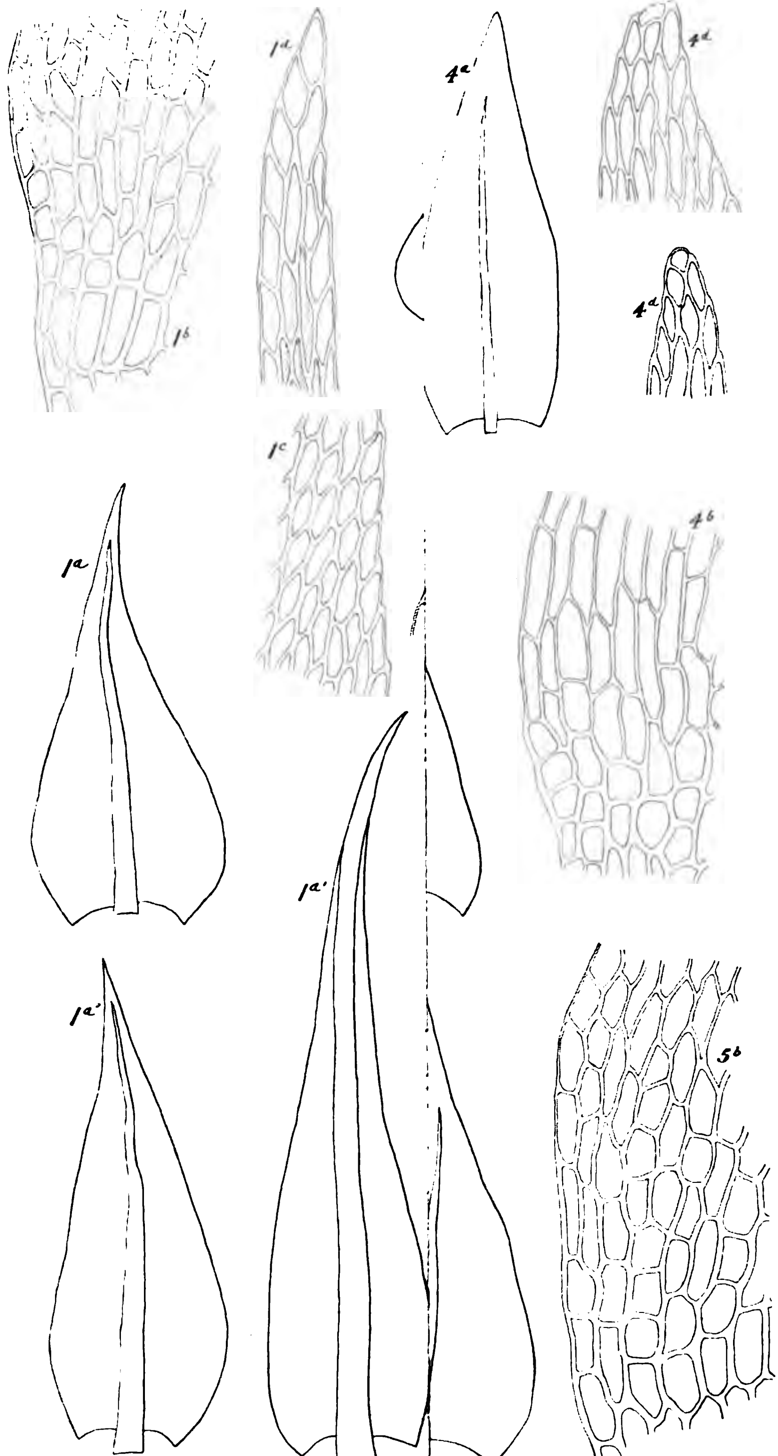
FIG. 1. *A. confervoides: a,* leaf; *b,* cells from the alar region; *c,* cells from the middle region in American plant; *c*[a], cells from the middle region in European plant; *d,* cells from the apical region in American plant; *d*[a], cells from the apical region in European.

FIG. 2. *A. sprucei: a,* leaf; *b,* cells from the alar region; *c,* cells from the middle region; *d,* cells from the apical region.

FIG. 3. *A. subtile: a,* leaf; *b,* cells from the alar region; *c,* cells from the middle region; *d,* cells from the apical region.

FIG. 4. *A. minutissimum: a,* leaf; *b,* cells from the alar region; *c,* cells from the middle region; *d,* cells from the apical region.




1b
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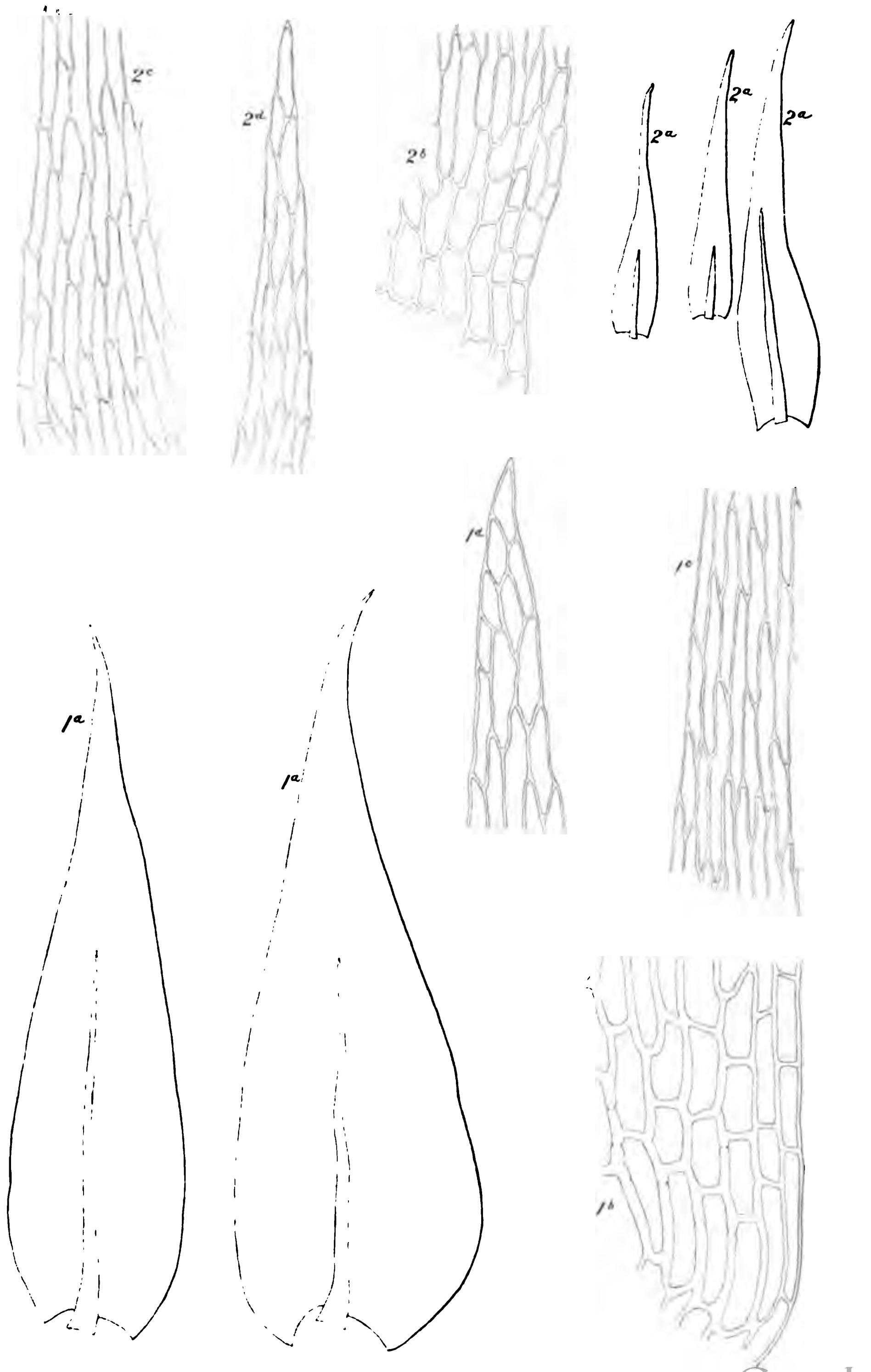
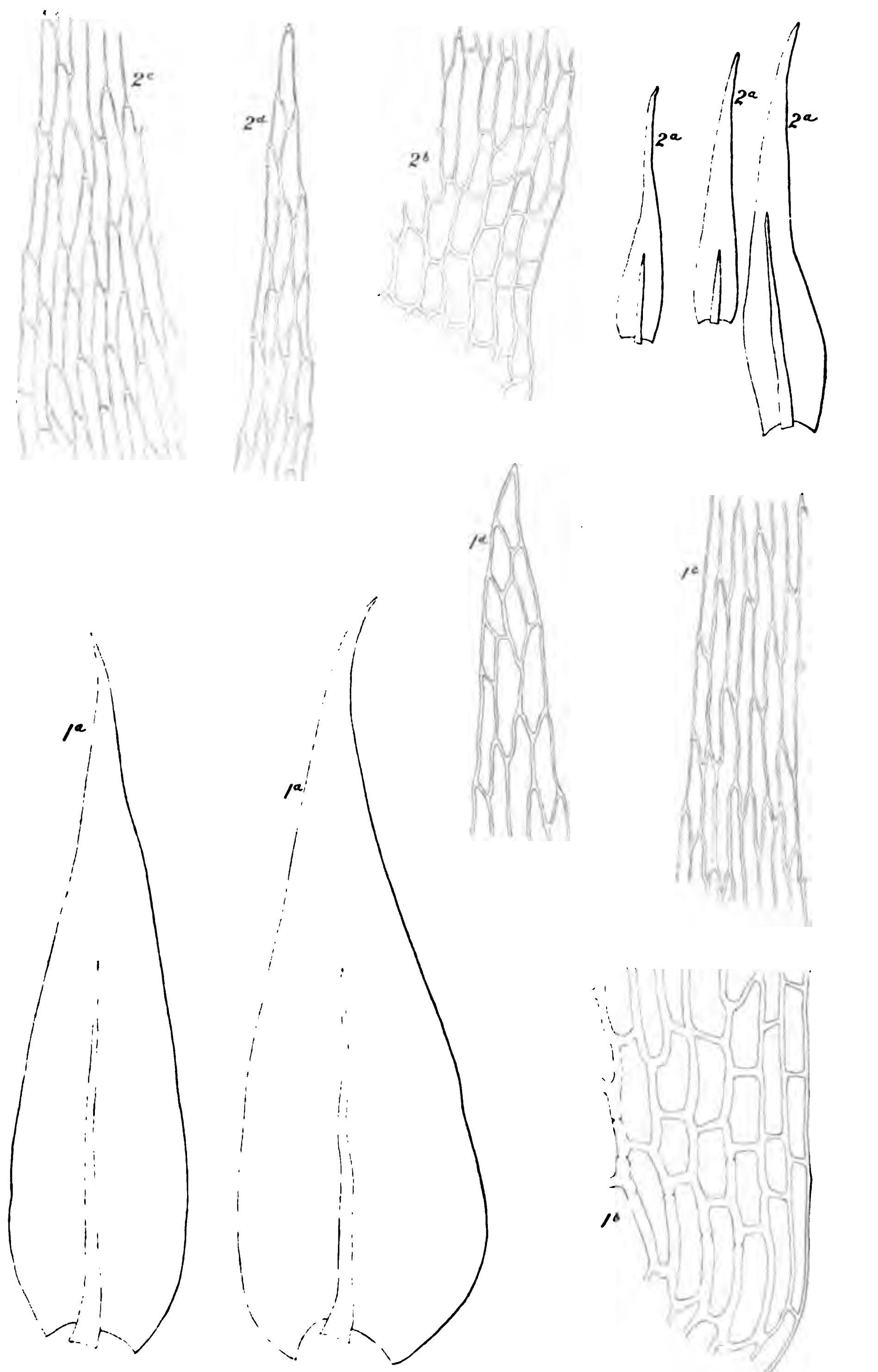


CHENEY on AMBLYSTEGIUM.



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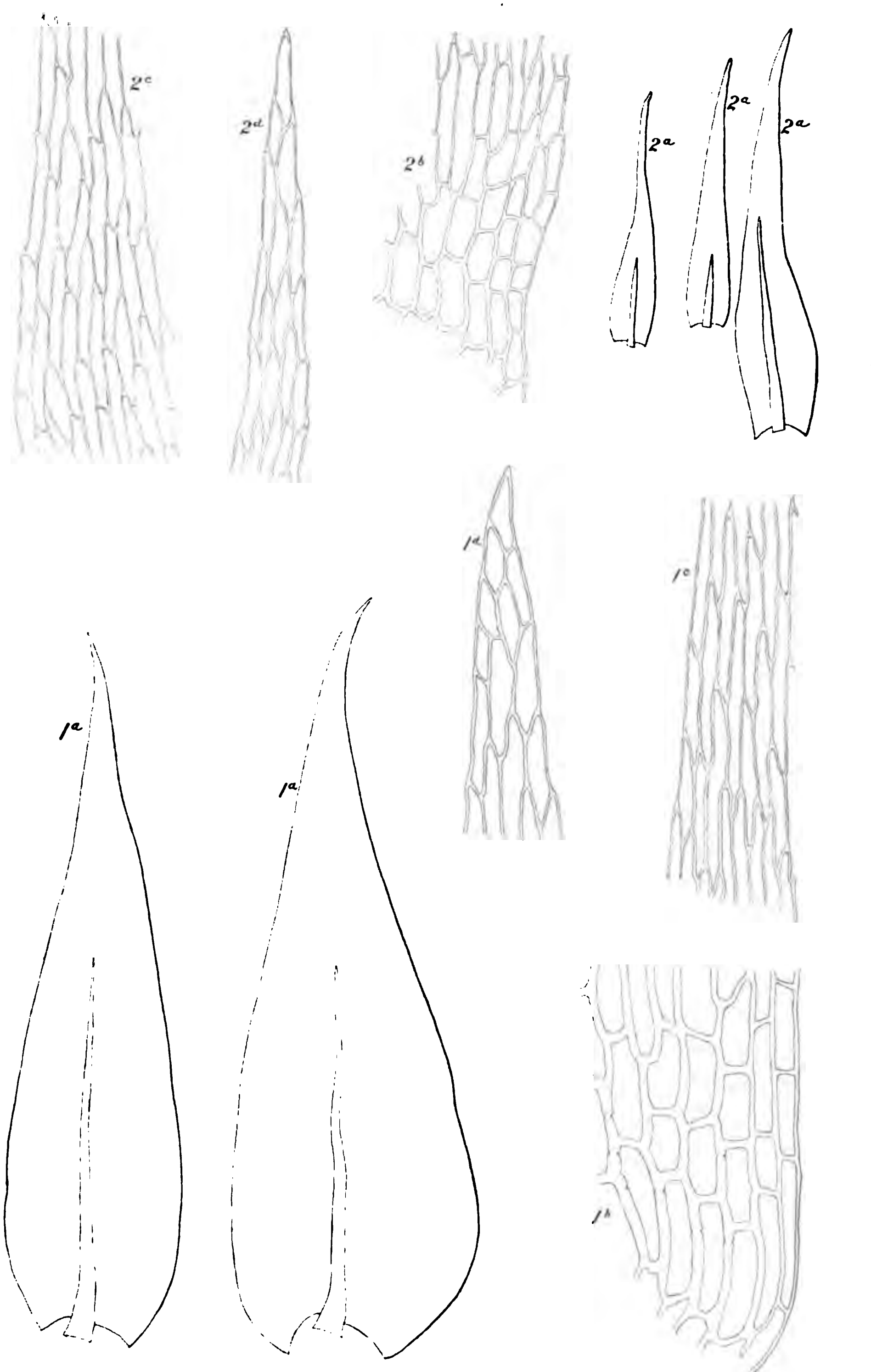

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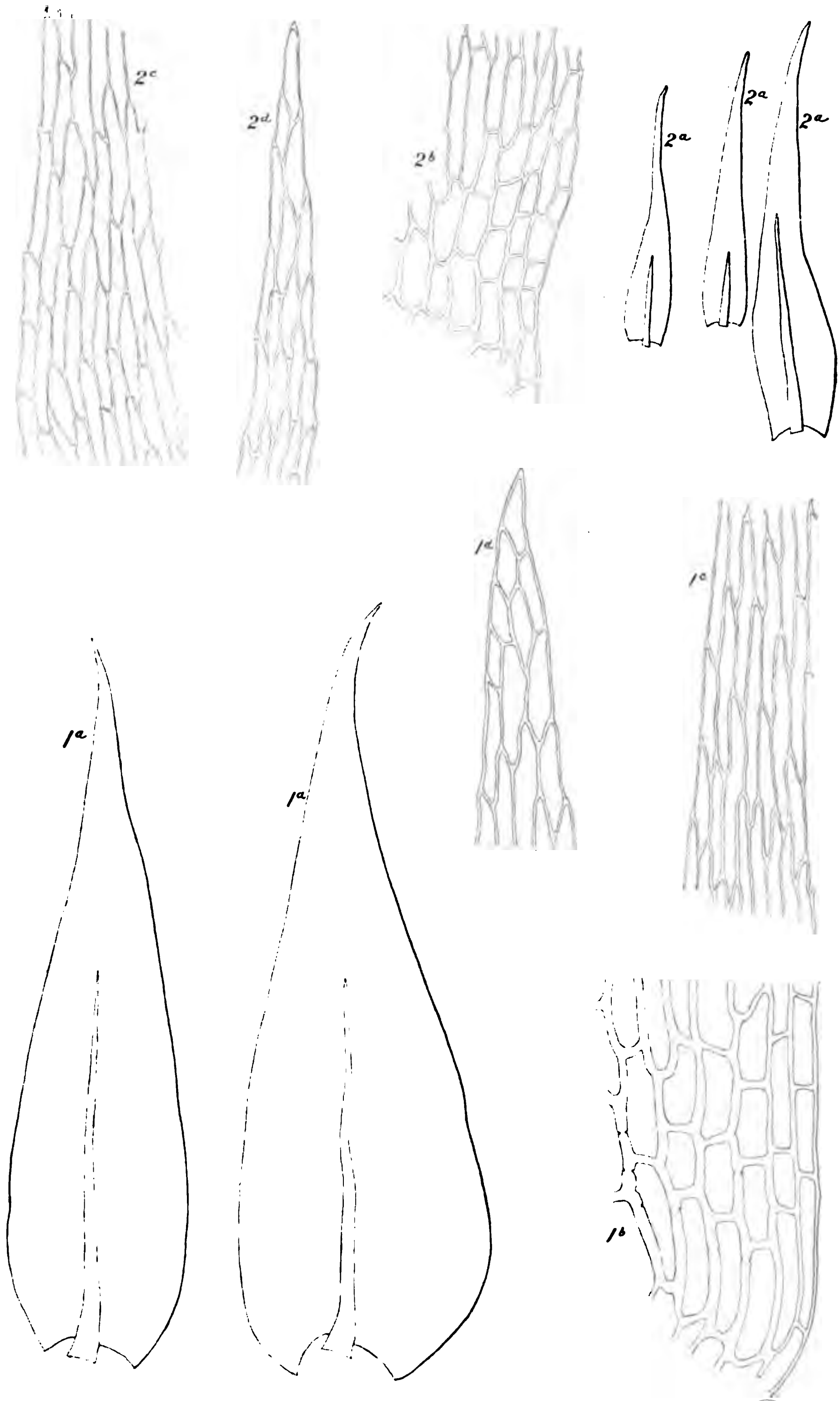

CHENEY on AMBLYSTEGIUM.

FIG. 5. *A. adnatum: a*, leaf; *b*, cells from the alar region; *c*, cells from the middle region; *d*, cells from the apical region.

FIG. 6. *A. serpens: a*, leaf; *b*, cells from the alar region; *c*, cells from the middle border region; *d*, cells from the apical region.

FIG. 7. *A. juratzkanum: a*, leaf; *b*, cells from the alar region; *c*, cells from the middle border region; *d*, cells from the apical region.

FIG. 8. *A. compactum: a*, leaf; *b*, cells from the alar region; *c*, cells from the middle border region; *d*, cells from the apical region.

FIG. 9. *A. lescurii: a*, leaf; *b*, cells from the alar region; *c*, cells from the middle region; *d*, cells from the apical region.

FIG. 10. *A. varium: a*, leaf; *b*, cells from the alar region; *c*, cells from the middle border region; *d*, cells from the apical region.

PLATE XII.

FIG. 1. *A. irriguum: a*, leaf; a^1, leaf of the variety *spinifolium*; *b*, cells from the alar region of a^1; *c*, cells from the middle border region of a^1; *d*, cells from the apical region of a^1.

FIG. 2. *A. fluviatile: a*, leaf; *b*, cells from the alar region; *c*, cells from the middle border region; *d*, cells from the apical region.

FIG. 3. *A. noterophilum: a*, leaf; a^1, leaf, terrestrial form; a^2, leaf, large aquatic form; *b*, cells from the alar region; *c*, cells from the middle border region; c^1, cells from the middle border region, terrestrial form; *d*, cells from the apical region of lamina; *e*, transections of the costa at the middle of the leaf and just above the lamina; *f*, transection of leaf near its base; f^1, transection of leaf near its middle; *g*, tip of the leaf of the large aquatic form; *h*, capsule.

FIG. 4. *A. vacillans: a*, leaf; *b*, cells from the alar region; *c*, cells from the middle border region; *d*, cells from the apical region.

FIG. 5. *A. kochii: a*, leaf; *b*, cells from the alar region; *c*, cells from the middle border region; *d*, cells from the apical region.

PLATE XIII.

FIG. 1. *A. riparium: a*, leaf; *b*, cells from the alar region; *c*, cells from the middle border region; *d*, cells from the apical region.

FIG. 2. *A. riparium floridanum: a*, leaf; *b*, cells from the alar region; *c*, cells from the middle border region; *d*, cells from the apical region.

BRIEFER ARTICLES.

VERNATION OF CARYA.

The bud of our common shellbark hickory, known in New England as walnut, is as beautiful as a flower. Its vernation and evolution are most interesting.

Before it opens, the very large bud consists of a series of imbricated scales, coarse and papery without, but as they are successively removed growing more delicate until finally they become of satiny sheen and texture. These inner scales are, moreover, pubescent, with close, silky

hairs. The shape of the scales changes rapidly with the centripetal advance. The outer and smaller ones are nearly orbicular. From this shape they broaden into ovate, and then into oblanceolate. It will happen in some buds, not in all, that scales will occur showing a retuse apex; then some more deeply emarginate and much narrower. Lastly, there will be one showing in the apical cleft a trace of true pinnation in the leaves.

The foliage proper consists of leaves, varying in number, standing erect upon the petioles and convolutely packed. Each of the leaflets is involutely rolled, and all are closely appressed. A sticky and sweetly odorous exudation helps to guard the leaves.

In full development the inner scales, several inches in length, become reflexed, and, with their beautiful salmon color, passing into green, or even of a rich claret red, resemble the petals of some gorgeous flower.—WILLIAM WHITMAN BAILEY, *Brown University.*

ABNORMAL LEAVES AND FLOWERS.

MR. FOERSTE'S interesting article on "Curious leaves" in the June GAZETTE induces me to place on record a couple of instances which I have lately observed here in Mesilla. One day Professor E. O. Wooton brought in a handful of *Clematis ligusticifolia*, which was placed in a bowl for ornament. Looking over it, I was surprised to see that many of the flowers had two of the petaloid sepals coalesced for more than half their length (*fig. 1*, from a dried flower).

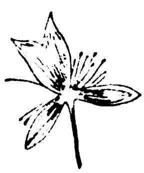

FIG. 1.

FIG. 2.

At about the same time, raising some *Solanum elæagnifolium* from seed, I found a seedling in which the cotyledons were coalesced for over half their length (*fig. 2*), so that the plant was no longer dicotyledonous.

These examples, as also, perhaps, Mr. Foerste's *figs. 1* and *2*, are the result of abnormal coalescence. In the case of Mr. Foerste's elm leaves the interpretation is more obscure; but at all events, they have nothing to do with the other cases figured (*figs. 3* and *4*) by Mr. Foerste, in which we have simply an arrest of the central axis.

There is a cottonwood (*Populus Fremontii*) here in Mesilla which

produces growths having the form of bunches of grapes, consisting of great numbers of stalks on a central axis, each bearing a dense rounded mass of small aborted leaves.—T. D. A. COCKERELL, *Mesilla, N. M.*

STOMATA ON THE BUD SCALES OF ABIES PECTINATA.

IN the Metaspermæ stomata occur on all normal leaves. They are also usually found on all of their well developed bud scales.

FIG. 1.—Dorsal surface of one of the bud scales of *Abies pectinata*, with stomata; *a*, a part of the axis and decurrent swelling, or pulvinus at the base of the scale; *b*, part of the scale which was covered over by the next lower bud scales, showing stomata; *c*, part of the scale which was exposed to the atmosphere. Epidermal cells thick walled and sclerotic. No stomata.

The needle like leaves of the Coniferæ are smaller, and hence have fewer stomata than the leaves of the Metaspermæ. On this account one would expect to find fewer or no stomata on their morphological equivalents, the bud scales. This has been found to be true, and it has always been thought that stomata never occur on the bud scales of the Coniferæ.

Grüss[1] says that stomata are never present on the bud scales of the Coniferæ. Schumann[2] makes the same statement. In a recent paper[3] the writer called attention to the occurrence of stomata on the bud scales of *Abies pectinata*.

Normal leaves of *A. pectinata* have stomata only on their lower surfaces, where

[1] GRÜSS, J.: Beiträge zur Biologie der Knospe. Jahrbücher für wissen. Botanik 23:642.

[2] SCHUMANN, C. R. G.: Anatomische Studien über die Knospenschuppen von Coniferen und dicotylen Holzgewächsen. Bibliotheca Botanica 15:3. 1889.

[3] Ueber abnorme Bildung von Harzbehältern, etc. Sonderabdruck aus der Forst.-naturw. Zeitsch. 1896. S. 15.

they are arranged in two bands, one on each side of the mibrid of the leaf. Each band is made up of from nine to fourteen rows of stomata. The stomata are never found on the midrib of the leaf.

The presence of stomata on the bud scales can best be demonstrated by mounting them in chloral hydrate. This clearing agent will make the scale more transparent, cause considerable swelling of the cell walls, and increase the guard cells of the stomata to their original size, rendering them visible from the exterior.

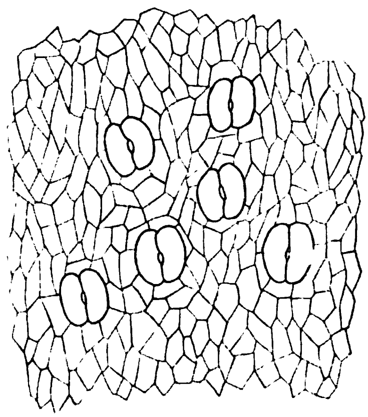

FIG. 2.—Highly magnified portion of dorsal side of a scale with stomata.

In the bud scales, as in their morphological equivalents, the leaves, the stomata are found only on the dorsal or lower surface of the scale. They are found only near the base of the scale and on that part of the epidermis which was covered over in the bud by the next lower scales. The cells of this part of the epidermis never become sclerotic, but remain thin walled (*fig. 1, b*). The exposed epidermal cells become sclerotic, and stomata never occur on this portion of the scale (*fig. 1, c*).

Stomata are found also on the axis of the bud and on the decurrent swelling or pulvinus of the scale (*fig. 1, a*). Stomata are found on the pulvini of all the scales, but on the scale laminæ they occur only on the larger and well developed ones. They are found on the outer or lower exposed scales, as well as on the inner or upper ones. The stomata are not as regularly distributed in rows as they are on the leaves. They are found isolated and in groups, occurring also on the midrib portion of the scale itself.—ALEXANDER P. ANDERSON, *Clemson College, South Carolina.*

CURRENT LITERATURE.

MINOR NOTICES.

A SEPARATE from the Transactions of the Wisconsin Academy of Sciences has been distributed by Dr. Davis.[1] In it 73 species of parasitic fungi are given that have been detected in the state since the publication of the last list in 1893, and additional hosts for 58 previously published species are recorded. *Entyloma Floerkeæ* Holw. and *E. Castaliæ* Holw. are probably described here for the first time; the latter occurs on Nymphæa and Nuphar. *Ustilago longissima macrospora* Davis is said to differ from the type in its "larger spores, 6–11 μ, mostly 8–9 μ in diameter."—J. C. A.

DR. WILLIAM TRELEASE[2] has published the results of his botanical observations on the Azores. The author visited those isolated islands in the summers of 1894 and 1896, and in addition to his own collections also enumerates plants previously reported from the islands. A brief discussion of the ecological features precedes the catalogue. There are few endemic species, and few pollinating insects. "The greater part of the Azorean flowering plants are either anemophilous or adapted to pollination by the aid of little-specialized insects, and, as a rule, they have open flowers with readily accessible nectar or pollen." The list includes cryptogams as well as phanerogams.—J. M. C.

IN CONTINUATION of his studies of Mexican and Central American plants, Dr. J. N. Rose[3] has just published an important contribution. Instead of reporting upon the many separate collections, a method which badly scatters material, Dr. Rose has determined to discuss genera, families, etc., upon the basis of all available material. In the present contribution the following subjects are presented: Notes on Celastraceæ; Notes on Rutaceæ, in which the genus Esenbeckia is enlarged to five species, three of which are figured; Notes on Burseraceæ; Notes on Cucurbitaceæ, among which is a discussion

[1] DAVIS, J. J.—Second supplementary list of parasitic fungi of Wisconsin. From Trans. Wis. Acad. Sciences 11: 165–178. 1897.

[2] TRELEASE, WILLIAM.—Botanical observations on the Azores. From the eighth Annual Report of the Missouri Botanical Garden, pp. 77–220, *pl. 12–66*, September 9, 1897.

[3] ROSE, J. N.—Studies of Mexican and Central American plants. Contrib. U. S. Nat. Herb. 5: 109–144. 1897.

of the genus Echinopepon and its allies, a number of new species being described and figured; A synopsis of the species of Heliocarpus, containing fifteen species; A synopsis of the American species of Hermannia; A synopsis of *Drymaria nodosa* and its allies; and Descriptions of miscellaneous new species, thirty-five in number, and with numerous illustrations.—J. M. C.

MR. CHAS. RICHARDS DODGE[4] has published the results of his long investigations among useful fibers. It is an enumeration of 1018 species of useful fiber plants, the more important of which are fully described and treated from the botanical, agricultural, and industrial standpoints. It is much more than a list of commercial species, for it is especially interesting in its presentation of the native fibers. The aboriginal American fibers have never before been brought together in such a complete way. The contribution is a great compendium of useful knowledge, to secure which Mr. Dodge has enjoyed special facilities. He is to be thanked for a very valuable contribution to the literature of economic botany.—J. M. C.

NOTES FOR STUDENTS.

A NEW AUXANOMETER is described by L. C. Corbett in the ninth annual report of the West Virginia Experiment Station for 1896. It is a lever instrument recording by pen upon a slowly revolving drum. The plant is attached to the short arm of the lever by platinum wire.

Other topics treated by the same writer are the greater vigor of northern grown seeds, bulbs, and cuttings, demonstrated by a large number of experiments; the behavior of cuttings, especially from tuber producing plants; and the injuries due to forest fires.

In the same report A. D. Hopkins discusses the life zones of West Virginia and the distribution of trees. The Canadian, transition, and upper austral zones can be traced, although the three marked areas of spruce, pine, and hard wood forests do not coincide with them. Three maps accompany the paper.—J. C. A.

RECENT BULLETINS from the experiment stations contain botanical matter of interest as follows: A. S. Hitchcock (Kas. no. 66, pp. 19–54) presents the fourth bulletin in a series on Kansas weeds, assisted by George L. Clothier. It is devoted to the fruits and seeds, including a description and illustration of each of the 209 species embraced in the list. The plates are

[4] DODGE, CHARLES RICHARDS.—A descriptive catalogue of useful fiber plants of the world, including the structural and economic classification of fibers. Report no. 9, U. S. Department of Agriculture. Fiber investigations. Pp. 361. *Pl. 1–12.* 1897.

admirably drawn, and bear the signature of Bertha S. Kimball. A key is arranged to aid in identification. J. W. Toumey (Ariz. no. 22, pp. 3–32) gives much general information about weeds of Arizona. In a list of 50 species nearly three-fourths are not known, or rarely seen, east of the Mississippi river. Sixteen species are singled out for more extended description, and twelve are illustrated. The only weed law of the state is directed against cockleburs and sunflowers along irrigating canals. A thick bulletin (Ore. no. 45) on prunes in Oregon, by four collaborators, contains a historical account of the varieties cultivated (pp. 21–33) and of the fungous diseases (pp. 63–75), written by U. P. Hedrick. An account of *Cicuta vagans* Greene is also given by U. P. Hedrick (Ore. no. 46, pp. 3–12, *pl. 4*). The underground parts are very poisonous while dormant, a piece the size of a walnut being sufficient to kill a cow. Two plates illustrate the plant, and two others show harmless species resembling it. F. H. Hillman (Nev. no. 33, pp. 3–13) gives notes upon a number of indigenous Nevada grasses, looking toward their utility as forage. In a bulletin by S. A. Beach (N. Y. no. 125) upon growing tomatoes under glass, two pages and one plate are given to a description of a peculiar black rot of the fruit written by F. C. Stewart. The cause was not ascertained. In the early stages no fungi or bacteria could be detected either by means of the microscope or agar cultures.—J. C. A.

DR. ROBERT BELL, of the Canadian Geological Survey, gave a very interesting address before the Royal Scottish Geographical Society at Edinburgh last March on the geographical distribution of forest trees in Canada. This address has recently been published with a map.[5] The author is exceptionally well fitted for this work by reason of forty years of observation throughout Canada. He states that there are 340 species of trees indigenous to the United States, 123 of which occur in Canada, 94 being found east of the Rocky mountains. *Pinus Banksiana* is mentioned as the only tree that may be considered as belonging to Canada, entering the United States only along the south shore of Lake Superior. It seems too bad to deprive the Canadians of the only tree to which they lay claim, but the species in question is very common about Lake Michigan, extending as far south as northern Indiana. The manuals also report *Pinus Banksiana* in Maine, Vermont, and New York. Some trees, especially the more hardy species, are said to taper off gradually in size as they approach their northern limits, while others, especially the more southern species, maintain their full size. The former habit would, of course, seem natural, owing to the gradually increasing rigor northward. Dr. Bell attributes the differences to the fact that the first type have better means of distribution (*e. g.*, seeds of conifers and poplars, fitted for wind dispersal), and have had time since the Pleistocene to occupy all territory congenial to their existence. The second type (including walnuts,

[5] Scot. Geog. Mag. 13: 281–296.

basswood, etc.) migrate more slowly, and are yet far from their rightful limits. Some of the trees of the second class have been transplanted successfully far to the north of their natural habitat.

The conditions governing distribution are listed as follows: (1) Distance or proximity of the sea. Most tree lines are more or less parallel to the Atlantic ocean and Hudson bay, as a rule appearing to shun the salt water. *Pinus Banksiana*, for instance, never comes to the coast, but appears almost everywhere else, even having outliers in the center of Nova Scotia and New Brunswick. *Populus balsamifera*, however, seems to love the sea, and is absent from a vast area in the interior. (2) Geological changes in arrangement of land and water. Some erratic lines, seen especially in the balsam poplar, are probably due to peculiarities in the distribution of glacier ice. *Thuya occidentalis* has the most remarkable line of all, turning abruptly southward both in the east and west; the cause in the east is thought to be the recent insular condition of Nova Scotia. This species has a large outlier 300 miles north of its regular line. (3) General dryness or moisture. Dr. Bell makes a strong argument for drought as the cause of treeless prairies rather than forest fires; the tree lines are not sharp but concentric, and the more hardy trees have their lines farther out into the dry region. (4) Extremes of heat and cold. (5) Local heat and moisture from lakes and rivers. This usually results in a further extension northward along river courses than on the uplands. (6) General elevation above the sea. This may account for the absence of the elm and black ash in a large interior area, since they occur on all sides of this region. (7) Local elevations. (8) Local depressions. (9) Diseases and insect pests. (10) Rapid or slow means of dispersion. (11) Forest fires. These are said to be frequent as natural phenomena. After a fire there springs up a low shrub and herb vegetation, then poplars, birches, and willows in about 20 years. Conifers dominate again in 50 years and reach maturity in about 150 years.—H. C. C.

THE WEEDS of Canada are treated briefly in a bulletin (no. 28) of 39 pages from the Central Experimental farm, prepared by Dr. James Fletcher. General methods for the control and extermination of weeds are given, followed by descriptions and illustrations of the following fourteen species of weeds possessing special interest: *Sisymbrium altissimum* L., *Arabis hirsuta* Scop., *Conringia orientalis* Andrz., *Neslia paniculata* Desr., *Thlaspi arvense* L., *Lepidium apetalum* Willd., *Saponaria Vaccaria* L., *Silene Cucubalus* Wib., *Hieracium aurantiacum* L., *Cynoglossum officinale* L., *Echium vulgare* L., *Salsola Kali Tragus* Moq., *Rumex crispus* L., and *Hierochloa borealis* R. & S. The first six species belong to the Cruciferæ. Much information regarding the more prominent Canadian weeds, numbering over one hundred and sixty species, is thrown into tabular form and made easy of reference.—J. C. A.

DR. J. P. LOTSY has concluded an elaborate study on the localization of alkaloids in cinchonas, the results of which, illustrated by twenty colored plates, are to appear in Dutch. In order to render the larger work more intelligible to foreigners, he publishes in German[6] a concise account of the more important results. These are as follows:

The alkaloid is found in the contents of living parenchyma, even the nutritive parenchyma. It is not found, however, in cells containing calcium oxalate, nor in sieve tubes. In general (there are exceptions) the alkaloid in young members is dissolved in the cell sap. On the contrary, in older parts, *e. g.*, in the secondary bast of stems, it exists as a solid amorphous substance in the interior of the cells. Very active parts, such as the cambium or the apical meristem, as a rule contain no alkaloid, but at a short distance from the centers of activity it is found in large amounts.

Dr. Lotsy announces that these researches are preliminary to an inquiry into the physiological rôle of the alkaloid in the plant, investigations in this direction having already been begun.—C. R. B.

IN THE *Botanisches Centralblatt* (70: 184–189. 1897) Dr. R. Kolkwitz, has a useful summary of the literature on the movements of swarm spores, spermatozoids, and plasmodia, and their dependence upon external factors. He covers the period from 1885 to 1896, and gives a list of 75 papers.—C. R. B.

AMANN recommends[7] the following fluid, which he calls lactophenol, as a medium for restoring dried mosses, algæ, etc., to their natural size, and for mounting them: crystallized phenol, c. p., 20^{gm}; lactic acid (sp. gr. 1.21), 20^{gm}; glycerin (sp. gr. 1.25), 40^{gm}; distilled water, 20^{gm}. Herbarium material should first be warmed in dilute lactophenol and then treated with the pure. Five per cent. lactophenol in water, to which is added 0.2 per cent. each of copper chloride and copper acetate, is specially adapted to the preservation of algæ.—C. R. B.

CHODAT has exposed spores and developing mycelium of *Mucor Mucedo* to a temperature of $-70°$ to $-110°$ C. for several days without killing them. The low temperature did not better the capacity of the spores for germination, as Eriksson found a temperature of $-12°$ C. did for spores of Uredineæ.[8]—C. R. B.

DR. J. GRÜSS summarizes the results of a recent installment of his "Studien über Reservecellulose"[9] thus:

6 Bot. Centralblatt **71**: 395. 1897.

7 Zeitschr. f. wiss. Mikros. **13**: —. 1897.

8 Bot. Centralblatt **70**: 242. 1897.

9 Bull. de l'Herbier Boissier **4**: —. 1896. Cf. Bot. Cent. **70**: 267. 1897.

In germination the diastatic enzyme penetrates from the cell lumen into the thickened cell wall, the more copiously the nearer the scutellum. [The seed under investigation was *Phœnix dactylifera.*] Upon the penetration of the enzyme there follows a fractional hydrolytic solution by which galactan is removed from the cell wall. This produces the hyaline marginal zone. The mannin remain ingin this hyaline zone succumbs to alloolysis; that is, the mass penetrated by the enzyme passes into various stages of mannin and finally into mannose. According to the reactions one can distinguish a leucomannin and a cyanomannin.—C. R. B.

PHYSIOLOGISTS will find in the *Pharmaceutical Review* for September two valuable articles touching the chemistry of plants. One is a summary of recent literature on oak bark tannins *à propos* of some researches on the caffein compound of kola (15: 172) by Knox and Prescott. The other is a résumé of progress in the chemistry of the carbohydrates during 1896, by W. E. Stone (15: 178).—C. R. B.

MONTEMARTINI has prosecuted researches upon the physiology of the primary and secondary meristem of various plants.[10] He finds that the activity of the growing point shows a grand period dependent upon internal factors. There exists a connection between apical and secondary growth; the curve of the former is parallel with that of the latter; the maximum of apical activity corresponds to the greatest elongation of the growing zone; both are equally affected by external agents. The secondary meristem shows a like periodicity, independent, however, of that of the apical region.

The author also discusses the formation of annual rings. He concludes (with Jost and Mer) that their production is an immediate consequence of spontaneous and periodic variations in the activity of the cambium, and (with Unger) that the periodicity of the cambial activity, though independent of that of the primary meristem, is synchronous with it and influenced, like it, by external conditions.—C. R. B.

ANCIENT EGYPTIAN bread taken from the tomb of Mentuhotep and now in the Royal Museum at Berlin is found by L. Wittmack[11] to still give the iodine test for starch. Microscopical study shows it to be made from barley, and to contain the remains of yeast and bacteria. This indicates that barley is probably older as a cultivated grain than wheat, and that yeast, or dough of the previous baking, was doubtless used in those ancient times. The bread is estimated to be fully 4400 years old.—J. C. A.

[10] Atti dell Istit. Bot. della Univ. di Pavia II. 5: —. 1896. Cf. Bot. Centralblatt 70: 276. 1897.

[11] Bot. Centr. 71: 328. 1897.

PROFESSOR BELAJEFF has recently published two preliminary papers announcing important discoveries in the spermatogenesis of Filicineæ[12] and Equisetineæ[13]. This author has previously given considerable attention to the process of spermatogenesis in various groups of plants, and his critical work on the spermatogenesis of the Characeæ led largely to the establishment of the view that the body of the spermatozoid is formed not only of the nucleus but also of the cytoplasm of the cell. His recent studies on the Filicineæ and Equisetineæ, he announces, have given him many opportunities to observe the correctness of this view. The main object of the present preliminary papers is to call attention to the office of an organ discovered in the spermatic cells, which ultimately forms a spiral band from which the cilia of the spermatozoid are developed.

In the spermatic cells of ferns, fixed with vapor of osmic acid and stained with a mixture of iodine green and fuchsin, small round bodies were found which stained very intensely. They are located in the cytoplasm near the nuclear wall, which is frequently somewhat indented at this point. These spheres reminded the author of centrosomes, and a careful examination was thus made of the dividing cells of the spermatic tissue. However, no indication of a centrosome could be detected. The first change which takes place in the spermatic cell is the gradual extension of this sphere, which becomes crescent shaped, and finally develops into a thread which encircles the nucleus. By a very careful examination the author was able to determine that this thread, which stains very intensely, runs along the edge of a lighter stained band which represents the first foundation of the body of the spermatozoid. It lies in the cytoplasm and stains bright red. In its further extension this band assumes the form of a spiral (apparently helicoid, judging from the author's description), of which the extended turns of the rear end encircle the nucleus, while the much smaller turns of the front end or apex of the spiral terminate free in the cytoplasm of the cell. The cilia, which are at first short but gradually increase in length, arise from the front end of this spiral and are directed backward. While the band is developing, the nucleus of the spermatic cell also undergoes considerable change. It begins to stretch out along the spiral band, becoming first reniform, then crescent shaped, and finally assumes a spiral form, the rear end of which is much the thickest. In the mature spermatozoid the hinder part consists of a spiral shaped, dense nucleus, which is surrounded by a layer of cytoplasm. On the rear end a continuation of the layer of cytoplasm forms an appendage. The front end of the spermatozoid has a band-like form, reacts the same as cytoplasm, and appears to be a continuation of the surrounding layer of cytoplasm. A thin

[12] Ueber den Nebenkern in spermatogenen Zellen und die Spermatogenese bei den Farnkräutern. Ber. d. deutsch. bot. Ges. 15: 337–339. 1897.

[13] Ueber die Spermatogenese bei den Schachtelhalmen. Ber. d. deutsch. bot. Ges. 15: 339–342. 1897.

thread, staining intensely with fuchsin, runs along the upper edge of this plasma band, which is the spiral thread or band formed by the extension of the sphere. The cilia, somewhat over forty in number, are attached to the two front turns of the spiral body of the spermatozoid, which in the mature condition does not have more than three turns.

In the spermatic cells of the Equisetineæ the bodies associated with the nucleus are not round as in the ferns, but crescent shaped, with the convex side turned toward the nucleus. Here, as in the ferns, the first change observed in the metamorphosis of the spermatic cell is in this body, which changes its form, turning its concave side toward the nucleus, around which it then begins to extend. It soon assumes a thread-like form and encircles the nucleus in the form of a spiral. Here also, as in the ferns, the writer was able to discover that an intensely colored thread runs along the edge of a less intensely stained band. The gradually elongating thread, which appears at first to be homogeneous, when it has completed its extension becomes granular. Small knobs then appear on the thread, which gradually become hook shaped, and finally extend into thread-like outgrowths, which form the cilia of the mature antherozoid. While the spiral thread and band are developing, the nucleus gradually elongates, as in the ferns, and finally assumes the form of a short spiral.

The mature spermatozoid has the form of a spiral with about two turns, and bears a large number of cilia on the front turn. The anterior portion of the spermatozoid appears as a comparatively small band, while the posterior portion forms a much thicker body and contains the nucleus which, as in the ferns, is surrounded by a sheath of cytoplasm. The thread which is formed from the crescent shaped body of the spermatic cell runs along the upper edge of the front end of the spiral.

In the Equisetineæ Belajeff was able to trace plainly the development of the cilia from the spiral thread formed by the extension of the crescent shaped body. In the ferns this connection was not traced, but from the analogy of the two cases, the author thinks there can be no doubt but that the spherical body (*Nebenkern*) in the ferns performs the same function.

By comparing these results with his previous studies of the spermatogenesis in Characeæ, the writer thinks that the tubercle (*Höcker*), which he found there in the spermatic cells, corresponds to the cilia forming body in the Equisetineæ. The tubercle, which has also been observed by Strasburger, lies near the nucleus, and becomes extended into a thread that ultimately bears the two cilia.

In a third preliminary paper Belajeff discusses the similarity of the phenomena of spermatogenesis in animals and plants.[14] The changes in the form

[14] Ueber die Aehnlichkeit einiger Erscheinungen in der Spermatogenese bei Thieren und Pflanzen. Ber. d. deutsch. bot Ges. 15 : 342–345. 1897.

and structure of the nucleus occurring in the metamorphosis of the spermatic cells of the salamander, as described by Flemming, the writer claims are similar to the changes which he has observed to occur in the spermatogenesis of the Filicineæ, Equisetineæ, and Characeæ. It is further pointed out that Hermann has described the occurrence of a small body (*Nebenkern*) near the nucleus in the spermatic cells of the salamander. Belajeff believes this *Nebenkern* to be homologous with the cilia forming body which he has discovered in the Equisetineæ and Filicineæ.—HERBERT J. WEBBER.

NEWS.

ASSISTANT PROFESSOR DR. W. DETMER, of the University of Jena, has been promoted to a full professorship.

PROFESSOR DR. HANS MOLISCH has left Prag for the winter, which he will spend in botanical research at Buitenzorg, Java.

PROF. DR. HUGO DE VRIES has declined the call to the University of Würzburg as the successor of Professor Julius von Sachs.

PROFESSOR A. W. BENNETT, long the editor of the department of botany of the *Journal* of the Royal Microscopical Society, has been made editor-in-chief.

IT IS ANNOUNCED that the ten years' supplement to the *Index Kewensis*, which brings the work down to the end of the year 1895, will be issued during the present year.

DR. W. ROTHERT, of Kazan, has been appointed professor of botany and director of the physiological division of the botanical department of the University of Charkow.

PLATES nos. 19 and 20 of Lloyd's Photogravures of American Fungi show *Lycoperdon pulcherrimum* B. & C. and *Trametes serpens* Fr., and are fine examples of most successful photographic work.

A VALUABLE REVIEW of publications on agricultural botany issued in France during 1896 is given in *Experiment Station Record*, nos. 10 and 11 (**8**: 841–853, 940–950). It was prepared by Edmond Gain of the University of Nancy.

DR. O. LOEW has given up his work in the Imperial University of Tokyo on account of impaired health. On the occasion of his departure a large gold medal was presented to him by his colleagues and students as a token of their appreciation.

PROFESSOR LESTER F. WARD recently delivered a series of five lectures, illustrated by lantern slides, on "The evolution of plants from the standpoint of paleobotany," before the students of the botanical and geological departments of the University of Chicago.

THE ADDRESS of Dr. William Trelease, on "Medical Botany," presented last June to the section on materia medica, pharmacy and therapeutics, at the forty-eighth annual meeting of the American Medical Association, at Philadelphia, has just been distributed as a reprint from the *Jour. Amer. Med. Ass.*

THE BOTANICAL SOCIETY of Western Pennsylvania (Pittsburg) has met with great success in its series of popular monthly lectures. The natural orders of plants were explained and illustrated by Mr. Wm. Falconer on the evening of September 2 to a crowded audience. The illustrative material represented 79 orders and 215 genera, and often several species for each genus; it was donated to the society by Mr. John Dunbar, of Rochester, N. Y., Mr. Henry A. Dreer, of Philadelphia, and the superintendent of Schenley Park, Pittsburg. This was the fourth lecture of the series.

ATTENTION should be called to another botanical journal which has entered the field as a popular magazine. *The Asa Gray Bulletin*, with its June number, ceased to be the organ of a chapter of the Agassiz Association, and entered upon the larger field. As was said in a recent notice of the newly established *Plant World*, there is abundant demand for a journal of this type. With G. H. Hicks as editor in chief, A. J. Pieters and C. C. DuBois as associate editors, and L. H. Dewey as business editor, we anticipate for the journal a most worthy support. *The Asa Gray Bulletin* is published bimonthly at Washington, D. C., and the subscription price is fifty cents.

WITH ITS September number, the *American Naturalist* comes into possession of new proprietors and under the charge of new editors. It makes no large promises, but seeks to define its *raison d'être*. The new editor, as already announced, is Dr. R. P. Bigelow, of Boston; while among the associate editors we find the names of the following botanists: C. E. Bessey, D. H. Campbell, H. M. Richards, E. F. Smith and W. Trelease. There is certainly a field for such a journal, and the responsible names connected with it are pledges of a very high character. In the first number the department of botany does not express itself very prominently, but it will doubtless make itself felt later.

AN INTERESTING LIST of the mycologic flora of the Kew gardens has been published in the *Bulletin of Miscellaneous Information* for April. It is a rich flora, as is perhaps to be expected when one considers the large annual influx of plants to Kew from all parts of the globe. "By this means microscopic fungi, parasitic or saprophytic, on plants are introduced in a living condition on the various hosts; whereas the higher forms, belonging to the Agaricineæ and the Gastromycetes, are usually included along with soil, or frequently on the trunks of tree ferns, either in the form of spores or in an undeveloped condition." It is interesting to note that the Polyporeæ and Thelephoreæ, so abundant in the tropics, are not represented in the list as

introduced species; and that Kew has never been responsible for the introduction into Europe of a single destructive parasite. The list enumerates 1340 species, representing 337 genera.

DR. J. N. ROSE returned from his Mexican trip early in October. His work was mostly confined to the little-known parts of the Sierra Madre. He visited Guaymas, La Paz (L. C.), Mazatlan, and Acaporeta on the western side, crossed the two ranges of the Sierra Madre north of the Acaporeta, and made two excursions into them, one from the west at Rosario, and the other from the east at Bolanos, the latter being one of Seeman's stations. The states chiefly explored were Durango, Jalisco, Zacatecas. and the territory of Tepic. The collection contains 2000 numbers, and is especially rich in umbellifers, agaves, and orchids, many living specimens of the two latter groups having been shipped for cultivation.

THE SEABOARD AIR LINE railroad, which extends from Portsmouth, Va., to Atlanta, Ga., has inaugurated a novel system of instruction of the communities along its territory. It began by encouraging tree planting and village improvement. During the present season it has been holding one-day farmer's institutes, all illustrative material and appliances, and the force of instructors being transported from place to place in a train of cars especially fitted up for the work. Another feature is the establishment of experimental farms every ten miles along the whole line; twenty-eight are now organized. Among the crops being tested are hops, ginseng, Kafir corn, and pyrethrum; fruits and grasses will be taken up in due course of time. Both the community and the railroad, and even the country at large, should profit by such well devised philanthropy.

THE LATE Dr. Edmund Russow, of the University of Dorpat (now officially known in Russia as Jurjew), left two important collections, which the widow desires to sell. One is a collection of about 3750 finely prepared and well preserved microscopical preparations. It is especially valuable because it includes the original mounts used for the late owner's classical investigations. Thus there are about 400 mounts connected with his investigations on the vascular cryptogams, including 125 of the anatomy and development of Marsilia, 22 of Pilularia, 32 of Equisetum, 37 of Lycopodium, 34 of Selaginella, etc. There are also the preparations for his notable investigations on wood, including 214 of Pinus, showing all ages and methods of treatment. It includes besides a set of 122 drugs. In general the preparations cover all families of phanerogams, among which might be named the Cycadeæ, Juncaceæ, Cyperaceæ, Gramineæ, Ranunculaceæ, and Cucurbitaceæ, which formed the original material for the author's publications. In the interest of science it is desirable that this collection be acquired by some institution where it may be accessible.

The second collection is the Sphagnum collection. Through his systematic and anatomical work on the Baltic Sphagnaceæ Russow was known as one of the foremost students of the group. He had intended to extend his monographic work when interrupted by death. The collection consists of 314 fascicles, and about 3000–4000 microscopical preparations, with outline sketches of the same, especially of the species which have been already worked up. In addition there are 300 photographic lantern slides of localities of the different sphagnums. It is much to be desired that this collection also be made generally accessible in some institution. It would be especially valuable for America, as it contains the European species, varieties, and forms completely and critically determined and worked over; and the exact relation of the American to the European sphagnums forms one of the interesting botanical problems. Further information regarding the collection may be obtained by addressing Frau Professor Emma Russow, Schloss-str. 15, Dorpat, Russia.

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COMPARATIVE ANATOMY OF THE NORMAL AND DISEASED ORGANS OF ABIES BALSAMEA AFFECTED WITH ÆCIDIUM ELATINUM.

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(WITH PLATES XIV AND XV)

I. INTRODUCTORY.

WITHIN the last few years some attention has been given to the study of the deformations and anatomical changes that take place in plants when attacked by parasitic fungi. Such changes become more marked when the relations between host and parasite are such that there exists a sort of mutualism between the two. In many cases the hypertrophied organs of the host plant lose their photosynthetic power, and thus, by assuming parasitism, become more dependent on the normal parts of the host for their existence. This is always true of the so-called "witch brooms" (Hexenbesen) on species of Abies affected with *Æcidium elatinum*. Here the affected and hypertrophied part of the plant becomes a morphological unit, the anatomy and physiology of which departs from that of its normal homologues.

The anatomy of different species of Abies varies slightly under normal conditions. This is especially true of the leaves and younger branches, which in some species have tissues and

structures that may be rudimentary or wanting in others. Such structural and anatomical diversity either becomes more marked, or is entirely lost in hypertrophied or atrophied organs.

The deformations and anatomical changes resulting in the hypertrophied branches of *A. pectinata*, affected with *Æ. elatinum*, were first described in a general way by De Bary[1] who demonstrated that the "witch broom" was caused by a fungus.

Later, Hartmann[2] made a comparative anatomical study of the diseased and the healthy leaves and branches of the same witch broom. The writer[3] has made a comparative study of the diseased and the healthy buds of *A. pectinata*, as well as the formation and distribution of the abnormal resin canals that are formed in the wood of the branches affected with the same fungus. By comparing the witch broom of *A. firma* Siebold of Japan with that of *A. pectinata*, it was found that differences occur in the two, depending largely upon the differences existing in the normal leaves and branches of the two mountain species of Abies.

According to the analyses of Mayr,[4] the wood of *A. pectinata* contains the least per cent. of resin of any of the cultivated firs. *A. balsamea* differs from *A. pectinata* and *A. firma*, not only in its specific characters and peculiarities, as a large resin or balsam producer, but also in being a swamp species. For this reason, as well as its being exclusively an American species, one would expect to find marked structural and anatomical changes in the affected leaves and branches. The anatomy of the *Æ. elatinum* witch broom of *A. balsamea* has not been studied.

For the purpose of making a comparative anatomical study of this witch broom, material was collected from trees growing in a bog near Walker, on Leech lake, northern Minnesota, September 1896.

[1] DE BARY: Ueber den Krebs und die Hexenbesen der Weisstanne. Bot. Zeit. 1867.

[2] HARTMANN, F: Anatomische Vergleich der Hexenbesen der Weisstanne mit den normalen Sprossen derselben. Inaug. Diss. Univ. Freib. 1892.

[3] Ueber abnorme Bildung von Harzbehältern und andere zugleich auftretende anatomische Veränderungen in Holze erkrankter Coniferen. Inaug. Diss. Univ. München, 1896.

[4] MAYR, HEINRICH: Durability of resinous woods. Pop. Sci. Monthly **28**: 680.

II. GENERAL CHARACTERS OF THE WITCH BROOM.

Æ. elatinum Alb. & Schw. usually attacks the younger lateral branches of *A. balsamea* (L.) Mill. which take the infection either in the young shoots, or in the wounded bark of older ones. Branches over five years old seldom take the infection, differing in this respect from *A. pectinata*, which often has large swellings on the older branches and on the main trunk, due to this disease. It often happens that the terminal shoot becomes diseased, in which case the whole tree soon dies from insufficient light, not being able to increase in height fast enough to keep out of the shade of surrounding trees.

The irritation due to the fungus mycelium causes an increased growth of the bark and wood at the first point of infection, producing a so-called "boil" or tumor on the diseased branch. This tumor is always present and increases in diameter with the increase in age of the witch broom. The diseased annual shoot is shorter, but has a greater diameter than the normal.

Owing to the development of a greater number of the latent and lateral buds of the affected branches, the number of the diseased branches above the normal is greatly increased. In this way a sort of broom is formed. The leaves of the diseased branches spread on all sides like the leaves of the erect terminal shoots. This is partly due to the fact that the terminal as well as the diseased branches are all negatively geotropic, unlike the normal lateral branches which are diageotropic. On account of the absence of chlorophyll the diseased leaves have a yellowish color. The leaves of the diseased branches are about one half as long as the normal leaves of the lateral branches, but they are usually of the same length as the leaves of the normal terminal shoots. The normal leaves of the lateral branches are arranged nearly in one horizontal plane, not because the phyllotaxis is altered, but because the leaves are twisted more or less at the base, just above the pulvinus. It is easy, therefore, to distinguish between the normal and diseased branches, the normal ones always having this apparent distichous leaf arrange-

ment, while in reality they are still polystichous, like the leaves on the terminal shoot.

The *Æ. elatinum* witch broom on *A. balsamea* differs from that found on *A. pectinata* and *A. firma*, in that it seldom has normal branches growing together with the diseased ones above the tumor. The diseased branches are also more numerous, but correspondingly smaller. With the increase in height of the tree, the lower normal branches and the affected branches soon die on account of an insufficient amount of light. The witch broom dies with them, since it is dependent on the normal host for its food supply.

Although that part of the witch broom branch below the tumor is not diseased, its annual growth in diameter is less than in normal branches of the same age. The supply of food is transported to the witch broom, which grows at the expense of the normal parts of the host. This increased growth of the witch broom makes it much heavier than the normal branches, so that it is usually found suspended from larger limbs of the tree, or hanging near the tree trunk when the whole branch is affected. The living and actively growing ones on older trees, excepting where the trees are isolated, are always found near the top, where there is a sufficient food supply. Although photosynthesis is almost entirely absent in the witch broom, it is extremely sensitive, and dies from an insufficient amount of light.

As to the size of the witch broom on *A. balsamea*, the average diameter is from 15 to 30^{cm}, and the length from 20 to 60^{cm}.[5]

III. ANATOMY OF THE NORMAL AND DISEASED LEAVES.

1. *Normal leaves.*—The leaves of Abies are sessile, and without the prominent pulvini peculiar to the spruces. The leaves of the lateral branches of *A. balsamea* are more or less flattened, notched, or obtuse at the tip, grooved on the upper surface and

[5] *Picea nigra*, which grows with *A. balsamea* in the bogs of northern Minnesota, often has a witch broom 40 to 90^{cm} in diameter. The broom is caused by an increase in the number of branches, the internodes of which remain shorter than in the normal. This witch broom is not caused by *Æ. elatinum*, but by some other fungus or insect (Compare v. Tubeuf, Forst-naturw. Zeitsch. — : 76. *pl. 5.* 1893.

with a somewhat prominent midrib or keel below. They are always twisted at the base, giving them the distichous direction peculiar to species of Abies. The leaves on the erect shoots are not transversely heliotropic, or twisted at the base, but grow in all directions from the shoot. They are shorter and thicker than those of the lateral branches, more or less awl shaped, and are sharply pointed at the tip.

The number and arrangement of the stomata seem to vary in different localities. Masters[6] finds that the stomata are chiefly on the upper surface of the leaf. McNab[7] in his description gives two or more rows of stomata in the middle line near the apex on the upper surface, with two or more rows on each side of the midrib on the lower surface. Bastin and Trimble[8] find the greater number on the lower surface. I find that by far the greater proportion of the stomata are on the lower surface of the leaves of the lateral branches, which have one band of from 3 to 10 rows on the upper surface, and two bands of 8 to 10 rows on each side of the midrib on the lower leaf surface. On both surfaces the stomata are found in greater numbers toward the apex of the leaf. The more or less terete leaves of the terminal shoots have their stomata distributed about equally on all sides.

Cross sections of the leaves show a well marked cuticle covering the lignified epidermal cells, the outer walls of which are cuticularized and much thickened. Immediately under the epidermis lies the hypoderm when present (*fig. 1*). As to the presence or absence of a hypoderm, McNab[9] says that it is wanting. Engelmann[10] found that the leaves have scarcely any hypoderm cells above, and very few on the edges and keel, fewer than any other species of Abies. Sometimes no hypodermal cells

[6] MASTERS, M. T.: Anatomy and life-history of the Coniferæ. Jour. Linn. Soc. **27**: 250.

[7] McNAB: New way of determining species of Abies. Robinson, The Garden **11**: 280.

[8] BASTIN and TRIMBLE: A contribution to the knowledge of some North American Coniferæ. Am. Jour. Pharm. **68**: 556.

[9] *Ibid.*, p. 280.

[10] ENGELMANN, G.: The American firs. Gard. Chron. N. S. **9**: 300. 1878.

were found. Bastin and Trimble[11] observed no hypoderm except along the midrib on the lower leaf surface. The presence or absence of strengthening, or hypodermal cells, however, depends entirely on the part of the leaf from which the cross sections are made. Hypoderm cells rarely occur in cross sections made above the middle of the leaf, while below the middle they are always present. Thus, numerous cross sections at five different parts of the leaves show in the following table their distribution (see page 315).

Longitudinal sections of the leaves show that the thick-walled hypodermal cells are long and bast-fiber like, with tapering, oblique, or blunt ends. The isolated cells are tapering at their upper ends and extend farthest up into the leaf. Their function, as is well known, is for strengthening the leaves. The leaves on the terminal shoots are much more rigid than the leaves on the lateral branches. This is due to the greater development of their hypoderm. Like the epidermal cells they are lignified. The walls are unequally thickened and often provided with pore canals. In *A. balsamea* one never finds them extending into the mesophyll, as they do in the leaves of *A. firma*. The number of hypodermal cells decreases from the base toward the tip of the leaf; but with the decrease in the number of hypodermal cells there occurs a corresponding increase in the number of stomata.

The mesophyll, which forms the chief substance of the leaf within the hypoderm, agrees in its main characteristics with that found in the leaves of most species of Abies. The two distinct layers of palisade cells extend around the rounded angles of the leaves. In the center of the mesophyll, and midway between the endoderm and outer angles of the leaf, lie the two circular resin canals, which are large in *Abies balsamea*. The resin canals are lined with the thin walled epithelial cells, which are themselves surrounded by one layer of thick-walled strengthening cells. These strengthening cells differ from the subepidermal ones in that they are shorter and not fiber-like.

[11] *Ibid.*, p. 556.

TABLE I.

CROSS SECTIONS OF LEAVES OF A. BALSAMEA, SHOWING THE DISTRIBUTION OF THE HYPODERMAL STRENGTHENING CELLS.

	Cross sections	Leaves of lateral branches	Leaves of terminal shoots
One millimeter above the base.	1. Upper surface. (Ventral.)	Hypodermal layer continuous, except where it is perforated by the stomata.	Hypodermal layer unbroken; often with double rows of cells.
	2. Lower surface. (Dorsal.)	Like 1. Layers often double at the midrib.	Like 1. Often with 2 to 4 rows of cells at the midrib.
	3. At the angles.	Single hypodermal layer unbroken.	Hypodermal layer consisting of 2 to 3 rows of cells.
Half way between middle and base.	1. Upper surface.	Hypodermal cells present, but more or less isolated.	Hypoderm unbroken, often double rowed.
	2. Lower surface.	Like 1, but more numerous, forming a continuous layer at midrib.	Like 1, often with three rows at midrib.
	3. At the angles.	Like 1.	Layer continuous, often double rowed.
At the middle.	1. Upper surface.	Hypodermal cells seldom present.	Hypodermal layer often broken by mesophyll and stomata cells.
	2. Lower surface.	Like 1. Single layer often continuous at the midrib.	Like 1, but never broken at the midrib where it is often double.
	3. At the angles.	Like 1.	Hypoderm unbroken.
Half way between middle and apex.	1. Upper surface.	Hypoderm wanting.	Hypodermal cells isolated when present.
	2. Lower surface.	Usually 2 to 5 strengthening cells at the midrib.	Hypoderm continuous at midrib. At other parts, cells isolated.
	3. At the angles.	Hypoderm wanting.	6 to 10 cells present in one continuous layer.
One millimeter below apex.	1. Upper surface.	Hypoderm wanting.	Hypodermal cells scattered and isolated when present.
	2. Lower surface.	Hypoderm wanting.	Like 1, but with a continuous layer of 8 to 15 cells at the midrib.
	3. At the angles.	Hypoderm wanting.	2 to 5 hypodermal cells usually present.

The elliptical endoderm or bundle sheath, which lines the mesophyll on its inner side, separating it from the central pericycle and fibrovascular bundle, consists of one very distinct layer of large, usually oval, non-lignified parenchyma cells.

The pericycle consists of more or less thickened, lignified parenchyma cells, destitute of chlorophyll. The greater part of it lies on the dorsal side of the leaf, while the vascular bundle occupies the ventral. The pericycle consists of two kinds of cells, forming two distinct areas. First, a central, well marked area with non-pitted cells, varying greatly in size and in the thickness of their cell walls (*fig. 2*). These cells separate with 2 or 3 layers the two divisions of the vascular bundle in the middle part of the leaf, where the bundle is bifurcated. They extend up into the ventral or xylem side of the bundle, forming a wedge shaped area of thick walled cells. On the phloem side they are thinner walled, but larger, and fill up the whole center of the pericycle, extending dorsally to the endodermis in the leaves of the lateral branches. But in the leaves of the terminal shoots, the non-pitted area is separated from the endodermis by a layer of the pitted parenchyma. Second, the pitted parenchyma of the pericycle, which forms the so-called transfusion tissue of von Mohl. This part consists of linear lignified cells with bordered pits on their ends, as well as on their lateral walls (*fig. 3*). The transfusion tissue is not as well developed in the leaves of the lateral branches as in the leaves of the terminal shoots. In the former there are two small areas, each one lying dorsal to the outer half of the two phloem areas. Each area of the transfusion tissue extends along the endoderm about one-eighth of its circumference. In the leaves of the terminal shoots the two parts of the transfusion tissue begin at the outer edges of each of the phloem parts and follow the endodermis until they meet, thus making a semicircular area of transfusion tissue, 2 to 6 cells deep on the dorsal side of the leaf beneath the endodermis. More than one-half of the pericycle of the leaves of the terminal shoots consists of transfusion tissues.

The vascular bundle lies near to the endoderm on the ventral

side of the leaf. At the base and apex of the leaf the bundle is undivided; but in the middle, and for the greater part of its length, it is bifurcated. The phloem part (dorsal) consists of smaller and less thickened cells than those of the xylem (ventral). The phloem and xylem cells are arranged in more or less distinct rows, usually separated by medullary rays. The cells of the medullary rays frequently contain crystals of calcium oxalate.

2. *Diseased leaves.*—The diseased leaves are about one-half to three-fourths as long as the normal ones on the lateral branches, but they have about the same length and thickness as the leaves of the terminal shoots. The diseased leaves growing, as they do, on negatively geotropic branches, are more or less homologous to the normal leaves of the terminal shoots. In comparing the anatomy of the diseased and the healthy leaves, those of the lateral shoots should be considered. In Hartmann's comparative anatomical study of the witch broom of *A. pectinata* the leaves of the lateral branches only are considered. The cuticle of the diseased leaves is less thickened than that of the normal leaves. The number of stomata and stomatal rows varies according to the size of the leaf, as well as to the severity of the mycelial infection. There are only about one-half as many stomata in the diseased as in the normal leaves.

The epidermal cells vary greatly in size; they have larger lumina than the normal and are less thickened, especially on their inner sides, which are seldom laminated, or provided with pore canals. The hypodermal cells are present, especially in the basal half of the leaf. They are more irregularly distributed, often forming nests and groups. The cells are often twice as large and thick walled as the normal hypodermal cells (*fig. 4*). As in the normal leaves, the number of hypodermal cells decreases from the base toward the apex, but with the decrease in the number of hypodermal cells an increase takes place in the number of stomata on the upper and lower leaf surfaces. On account of the unequal thickening and irregular distribution of their epidermal and hypodermal cells, the diseased leaves shrivel

up on drying, soon after the ripening of the æcidia. The epidermal and hypodermal cells are lignified.

The mesophyll is made up of a mass of large, irregular cells, with large intercellular spaces. There is no differentiation into palisade tissue and spongy parenchyma. The fungus mycelium is found in all the cells and intercellular spaces. The two resin canals are also present in the diseased leaf. Their epithelial cells are usually larger and more irregular than the normal. The strengthening cells are not thickened, hence the resin canals become irregular in form and size, and often lose their identity in older leaves.

The endoderm is seldom distinguishable as such, its cells forming no ring.

The two lignified parenchyma areas of the pericycle are well defined, especially at the basal portion of the leaf. The transfusion tissue is nearly always present, often in one to three small areas on the dorsal side of the phloem part of the vascular bundle. In well developed leaves, especially in sections made near the base, the transfusion tissue fills up more than one-half of the pericycle. It is unlike the pitted parenchyma of the normal pericycle, in that its cell walls have simple as well as bordered pits. The cells are also irregular in form, and often thicker walled. The bordered pits are often twice the size of the normal (*fig. 5*).

The non-pitted parenchyma of the pericycle differs from that in the normal, in that its cells are always thicker walled and usually larger, but fewer in number. The two or three layers of cells, separating the bifurcated bundle, as well as the cells of the wedge shaped portion on the ventral side of the bundle, consist mainly of thick walled fibrous cells, which are seldom found thickened in the normal leaves (*fig. 6*).

The vascular bundle is double excepting at the base and apex of the diseased leaf. The phloem cells are larger, and the xylem cells thicker walled, than in the normal. They are not arranged as regularly in rows, and the rows, when distinguishable, are not separated by medullary rays, these being absent in the diseased leaves.

In the following table the most important differences in the structural units of the normal and diseased leaves are given:

TABLE II.

TABLE SHOWING THE COMPARATIVE ANATOMY OF THE NORMAL AND DISEASED LEAVES OF A. BALSAMEA.

Leaf structures	Normal leaves	Diseased leaves
Cuticle.	Well developed. Smooth on outer surface, irregularly thickened on the inner, fitting closely between the somewhat irregularly thickened and projecting epidermal cells.	Cuticle present, but less developed.
Epidermis.	Cells thicker walled on outer than inner sides. Often laminated and provided with pore canals.	Epidermal cells more irregular than in normal; less thickened and seldom laminated, and provided with pore canals.
Stomata.	More on lower than on upper leaf surface. The number increases from base toward apex as the number of hypodermal cells decreases.	Like the normal, but fewer on both surfaces. Bands of stomata have fewer rows.
Hypoderm.	Well developed at basal half of leaf. Number of cells decreases from base toward apex as the number of stomata increases.	Hypodermal cells fewer, but usually larger, thicker walled and more irregular than in normal leaves. Cells often aggregated.
Mesophyll.	One to three layers of palisade cells on ventral side, rich in chlorophyll. Remaining part consists of spongy parenchyma.	No distinction between palisade cells and spongy parenchyma. Chlorophyll rarely present.
Resin canals.	Circular or nearly so. Consisting of two layers of cells — epithelial and strengthening. The latter are thick walled.	Irregular; varying in form and size, on account of the absence of the layer of strengthening cells.
Endodermis.	One layer of oblong or elliptical, thin walled cells, forming a regular ellipse bounding the mesophyll and pericycle.	Endodermis seldom distinguishable. Cells irregular in form and size. No distinct boundary between mesophyll and pericycle.

TABLE II.—*Continued.*

Leaf structures	Normal leaves	Diseased leaves
Transfusion tissue of the pericycle.	Always present. Cells have bordered pits only. Cells lignified.	Nearly always present. The lignified parenchyma cells unequally thickened. Cells have simple as well as bordered pits. Bordered pits larger than normal.
Non-pitted parenchyma of the pericycle.	Lignified parenchyma cells varying in size and thickness of their walls. Found on both sides, but mostly on the dorsal side of the bifurcated bundle.	Lignified; more irregular in form and size. Larger and thicker walled than in normal. Cells often fiber like.
Fibrovascular bundle.	Phloem and xylem consisting of from 5 to 10 rows of cells. Rows usually separated by medullary rays, the cells of which contain crystals of calcium oxalate.	Phloem and xylem less developed than in normal. The cells are often larger and thicker walled. Medullary rays and crystals of calcium oxalate are absent.

IV. ANATOMY OF THE NORMAL AND DISEASED BUDS.

1. *Normal buds.*—The buds of *A. balsamea* are conical or globular. In winter condition they are covered by a layer of resin 1 to 2^{mm} thick at the apex of the bud. The bud scales are destitute of any epidermal hairs, but the edges of the outer exposed scales, as well as the inner ones, are fringed with marginal hairs. The number of bud scales does not vary much in different buds, the smaller and lateral ones usually having the same number as the larger and terminal ones. The scales of the terminal buds are relatively larger.

The epidermal cells of the outer surface (morphologically the under surface) of the exposed scales are usually oblong, and 2 to 8 times as long as broad, usually with oblique ends. When viewed from the exterior, and in cross sections, they are found to be about twice as deep as broad, which is due mainly to the thickened outer wall of the exposed epidermal cells. This thickening of the outer wall is greater in the center of the exposed cell wall; hence, the outer wall of each epidermal cell

appears in cross sections as a protuberance from the cell. The thickened walls shows a laminated structure. The side walls are not thickened except at places where the thickening has proceeded from without inward, often unequally, so that pore canals are formed. These are best seen when the scales are mounted in chloral hydrate and viewed from the exterior. The inner wall usually remains unthickened. Variations, however, occur in the different parts of the bud scale in this and other species of Abies. Thus Schumann[12] found that in the upper part of the bud scales of *A. pectinata* the epidermal cells are thickened on all their sides. This I find takes place in *A. balsamea* also. The second, or hypodermal layer of cells, remains thin walled. The epidermis on the inner side (morphologically the upper) of the exposed scales, together with the second or hypodermal layer of cells, is usually thickened equally on all sides. The epidermal cells of the inner scales covering the growing point are thin walled like the cells of the mesophyll.

I have not succeeded in finding any stomata on the bud scales of *A. balsamea*. It is quite possible, however, that they occur, but if present, they are less frequent than in bud scales of *A. pectinata*, where I have found them, contrary to the statements made by Grüss[13] and Schumann,[14] who both say that they are never found on the bud scales of *A. pectinata*, even in a rudimentary condition.

The mesophyll or parenchymatic portion, homologous to the mesophyll of the normal leaf, is composed of from three to six layers of parenchyma cells, many of which contain chlorophyll.

The margins of the outer, as well as of the inner scales, are fringed with filamentous or hypha-like hairs (*fig.* 7). Although the marginal hairs of the outer scales are exposed to the atmosphere, they still remain thin walled, differing in this respect from the exposed epidermal cells and hairs, which always become

[12] SCHUMANN, C. G.: Anatomische Studien über die Knospenschuppen von Coniferen und dicotylen Holzgewächsen. Bibliotheca Botanica 15:3. 1889.

[13] GRÜSS, J.: Beiträge zur Biologie der Knospe. Jahrbücher f. wiss. Bot. 23:642.

[14] *Ibid.*, p. 2.

thickened and cuticularized. Tubeuf[15] finds the marginal hairs only on the inner scales of the buds of *A. pectinata*. They are present, however, and always found on the outer scales, also, not only in *A. pectinata* but in all species of Abies whose buds are in their winter condition covered with a layer of resin. The marginal hairs of the outer scales are always filled with resin.[16] With the drying of the cells of the marginal hairs, which always remain thin walled and connected with the mesophyll, through which the resin canals run, the resin passes from the resin canals and inner cells to the exterior, until the bud is covered with a layer of resin sufficiently thick to prevent any further transpiration of moisture and exudation of resin.

The endodermis cannot be distinguished. The central bundle with its pericycle is composed only of a number of smaller aggregated cells in the center of the scale. No differentiation into xylem and phloem is present.

A striking character in the structure of the bud scales of *A. balsamea* is that from two to six resin canals are often present in each scale. The greater proportion of the scales have two canals, the normal number of their morphological equivalents, the leaves, but in cross sections of many scales, especially the inner ones, one often finds in every bud some scales which have from two to six resin canals (*figs. 8* and *9*). As to the origin of the increased number of resin canals, whether they are due

[15] TUBEUF: Haarbildungen der Coniferen. Forst.-naturw. Zeitsch. 1896. Sonderabdruck S. 19 u. 21.

[16] Since the resin canals do not open to the exterior of the bud scales or any other part of the plant, there can be no doubt but that there exists a definite relation between the marginal hairs of the bud scales and the exudation of resin on the buds. It is evident that the resin, which begins to exude in the late summer and fall, as soon as the scales begin to dry up, must diffuse through cell membranes. That resin diffuses through cell walls has been demonstrated (compare Grüss, *ibid.*, p. 642; Mayr, *Pop. Sci. Monthly* **28**: 680; and Harz der Nadelhölzer 80. 1894). It does not, however, diffuse through the cuticularized and thick walled epidermis cells of the outer scales.

In many conifers. *e. g.*, *Picea nigra* and *P. excelsa*, whose buds are not resin-covered, the bud scales are coriaceous and destitute of resin canals. The marginal hairs of the outer scales of *P. nigra* are thick walled and the inner scales seldom have any marginal outgrowths.

to the branching of the two canals already present, or whether they are peculiar to the scales of *A. balsamea*, I am not able to state. It appears, however, that in all species of Abies whose buds are covered over with resin in the winter, there is an increase in the amount of resin production in the bud scales over that produced in the normal leaves, and hence it is probable that more than the normal number of canals can develop in the bud scales. The resin canals are seldom surrounded by a layer of strengthening cells.

The growing point with its rudimentary leaves is covered over by the inner scales, which are imbricated, and cover the apex of the growing point four to six layers deep. Longitudinal sections of the growing point show that in its winter condition no tissue differentiation whatever has taken place. The central portion (plerome) has pith characters. In cross sections no resin canals or rudimentary bundles are present.

The septum (Knospenscheide or Scheidewand), which makes the break in the pith at the annual nodes in most species of conifers, is well developed in buds of *A. balsamea*. It consists of from six to ten layers of thick walled cells, forming a diaphragm, separating the pith of the growing point and young shoot from the pith of the last year's internode. Immediately below the diaphragm there is always to be found a mass of loosely connected, rounded pith cells (*fig. 10, f, g*), which in older internodes have separated from the septum, or diaphragm, so that a cavity is formed. This empty chamber is seldom present below the septum of the bud in its winter condition. In the spring, however, as soon as the differentiation of the peripheral cells of the plerome begins, and the xylem cells of the vascular bundle begin to elongate, the septum is partly raised above the loose tissue of the pith of the last year's internode, thus forming the pith chamber, which is always present below the septa of the first and second year old and older internodes.

Fritsch[17] found that the cells of the septum are in the form

[17] FRITSCH, CARL: Die Marklücken der Coniferen. Schriften d. Kgl. physik. Ökonom. Gesellschaft zu Königsberg **25**: 50. 1885. [Separat-Abdruck p. 6.]

of irregular three to four sided prisms, whose sides are more or less arched. In cross sections the cells appear to be pressed together in the direction of the long axis of the stem, their lumina being longest in the radial direction. The cells are about equally thickened except where the pits appear to meet, being separated only by the primary cell wall.

As has already been stated, the leaves of Picea have prominent pulvini at their bases. Masters[18] calls attention to the fact that the central fibrovascular bundle of the leaf passes directly from the axis into the leaf, and does not traverse the prominent swelling at the apparent decurrent base of the leaf. The pulvini, therefore, do not form a part of the leaf, being mere outgrowths from the sub-epidermal and corky layers. In buds of Picea, especially in the terminal buds,[19] these swellings or pulvini are collected into a mass surrounding the bud. On this account the bud appears swollen beneath the bud scales, which, like the leaves, have these swellings and thus aid in making the basal portion of the bud assume this fleshy character.

The same is true in species of Abies, except that the apparent decurrent basal swellings of the leaves are much less marked.

The terminal shoots and buds of *A. balsamea* show to a great extent the same characters as those of Picea, the buds having he characteristic swelling below the bud scales. The bud scales are also provided with thickened bases, which in their compact arrangement in the bud have lost their decurrent aspect. The basal swellings of the innermost (uppermost) bud scales, covering the sides and apex of the growing points, differ essentially in structure from the lower and outer scales in that they consist of a mass of thick walled cells, very similar in structure to the cells of the pith septum, above which they project (*fig. 10, c*). In cross sections made at the base of the septum, a ring of this collenchymatic tissue can be seen in the section (*fig. 10, b*). Busse[20]

[18] MASTERS, M. T.: Note on the relation between morphology and physiology in the leaves of certain conifers. Jour. Linn. Soc. Bot. **27**: 547. 1879.

[19] Compare Tubeuf, *ibid.*, p. 19.

[20] BUSSE, W.: Beiträge zur Kenntniss der Morphologie und Jahresperiode der Weisstanne. Flora **77**: 121.

calls the ring of this tissue in *A. pectinata* the wall of the cup, the pith septum being its bottom. The wall of this cup surrounds the growing point in winter; the youngest inner bud scales grow from this annulus. That this annulus of thick walled tissue at the base of the innermost scales does not form a part of the internodal pith septal layer is shown by the fact that the xylem and phloem cells of the last year's internode extend up, and separate the septum from the basal swellings of the inner scales (*fig. 10, a*). In older internodes it is found dried up in the outer bark, together with the remains of the bud scales. The thick walled area of the basal swelling of the inner scales is composed of from 6 to 10 layers of cells of parenchymatic origin, shown by their pitted walls. That this annulus of strengthening cells, together with the pith septum, forms an additional protection to the bud in its winter condition, there can be no doubt.

TABLE III.

	Bud no.	Position	Diameter in mm.	No. of scales exposed	No. of inner scales	Total number of scales
Normal buds	1	Terminal on erect shoot	4	20	9	29
	2	" " " "	4½	20	10	30
	3	Axillary on erect shoot	2½	17	7	24
	4	" " " "	2½	19	8	27
	5	Terminal on lateral shoot	2½	16	8	24
	6	" " " "	3	19	7	26
	7	Axillary on lateral shoot	2	16	9	25
	8	" " " "	1½	18	6	24
Diseased buds	1	Terminal	2½	30	8	38
	2	"	2½	27	9	36
	3	"	3	29	7	36
	4	Axillary	1½	25	6	31
	5	"	1¾	27	7	34
	6	"	1½	24	6	30

2. *Diseased buds.*—The diseased buds are more numerous, shorter, and somewhat larger than the normal. They are covered with a layer of resin, and in this respect are well protected. Like the normal buds their scales have no epidermal hairs. The diseased buds are covered over with a greater number of bud scales

which are smaller than the normal. In the third table the number of exposed and of inner scales of normal and diseased buds are given.

From the above table one sees that the number of the inner scales does not vary much in the normal and the affected buds. The number of exposed scales, however, have been increased from 16 to 20 in the normal, to 24 to 30 in the diseased buds. More of the diseased scales are, therefore, provided with a cuticularized and sclerotic epidermis than the normal. The total number of scales has also been increased from 24 to 29 in the normal to 30 to 38 in the diseased.

One reason for this increase in the number of scales in the diseased buds is their relative smaller size. The buds thus require more scales to cover the growing point, which is also larger in diseased than in healthy buds.

The diseased scales, like the normal, have no stomata. The marginal hairs are present and as in the normal scales remain thin walled. Those of the outer scales are always filled with resin soon after the resin exudation begins.

The outer exposed epidermis is composed of shorter and more irregular cells than that of the normal. Cross sections of the scales show that the outer wall of the epidermal cells is thickened and cuticularized. The thickening never extends to the side or inner walls. The walls are not more than half as thick as in the normal epidermal cells. The inner, upper epidermis is rarely thickened excepting at the base of the inner scales.

The mesophyll, which is less developed than in the normal scales, consists of larger but fewer cells. The resin canals are fewer, more irregular in size and form; more than two are never present. They contain fewer epithelial cells, which vary greatly in size. Many of the diseased bud scales have no resin canals.

The endodermis, pericycle, and central vascular bundle, which in the normal scales have been reduced to a few cells, smaller than the surrounding mesophyll cells, are not found in the diseased scales.

The bases of the inner scales have the same fleshy tissue composed of thickened, strengthening, and protecting cells. This tissue, as in the normal buds, projects above the base of the young growing point. There is no difference whatever in the development of this tissue in the normal and the diseased scales.

The rudimentary leaves and apex of the growing point are larger, being composed of larger cells than the normal. This is especially true of the pith or central plerome cells. No resin canals are present in the growing point. The pith septum at the base of the growing point is composed of about the same number, and of equally thickened, but fewer pitted cells than the septum of the normal bud.

The distribution of the fungus mycelium in the diseased bud varies in the different structural units. It is always found in the mesophyll of the bud scales where the haustoria penetrate into almost every cell, except the resin canal and epithelial cells surrounding the canals. The same is true of the resin canals of the diseased leaves. The mycelium also is present in the loose pith tissue below the septum. All the remaining parts of the bud are destitute of the fungus mycelium. It is never found in the growing point and rudimentary leaves, nor in the internodal pith septum and similarly thickened cells, forming the ring of projecting tissue surrounding the growing point at the base of the inner bud scales. It is not surprising to find that the mycelium is absent in the thick walled cells of the septum, and in the annulus surrounding the lower half of the growing point, since the cells of this tissue have no cell contents whatever, nor does the mycelium penetrate the thickened cell walls. On the other hand it is surprising not to find the fungus mycelium in the growing point and rudimentary leaves, which are covered over with the inner scales. In almost every cell of these scales the actively growing fungus mycelium is present. This absence of the mycelium in the growing point is undoubtedly due to the presence of negatively chemotropic substances, or to periodic variations in the amount of starch, tannin, and

other plant products, occurring at different seasons of the year. Thus Busse[21] found that the maximum amount of starch in the growing point of *A. pectinata* occurs in May, and that from this month on there is a decrease until in the fall and winter, when the minimum is reached. He found also three different tannins in the growing point, varying in amount at different seasons of the year.

It often happens that buds are found which have been killed by the mycelial infection of the growing point. That this infection has taken place from the inner scales there can be no doubt, since the mycelium hibernates here, and infects the rudimentary leaves and young shoots as soon as they begin to develop in the spring. The mycelium is thus evenly distributed in the bark of all diseased shoots above the tumor of the affected branch. If it were not for this mycelial infection of the young shoots and rudimentary leaves by the bud scales and parenchymatic tissue of the primary cortex, healthy leaves would be found on affected branches. This never occurs. It often happens, however, especially on the witch broom of *A. pectinata* and *A. firma*, that the leaves and young shoots are not infected. They then develop like the normal. This shows that the mycelium does not spread to any great extent in the bark after the tissue differentiation has taken place. The mycelium never spreads more than 2 to 3^{mm} each year in the healthy bark below the swelling or tumor.

V. ANATOMY OF THE NORMAL AND DISEASED SHOOTS AND BRANCHES.

1. *Normal shoots and branches.*—The leader or terminal shoots depart in their general characters from the lateral, not only in the morphology and anatomy of their leaves, but also in the anatomy and morphology of their axes. The leader shoots are longer and have a greater diameter than the lateral. This greater diameter is due mainly to the greater development of the pith and primary cortex, the most important conducting tissues of the first year's internode. The vascular bundles of

[21] *Ibid.*, p. 170

the first year's terminal and lateral shoots are about equally developed. In the second year's growth, however, the vascular bundle, especially the wood of the terminal shoots, shows a decidedly increased growth over that of the lateral. Thus cross sections of the main and lateral axes taken from the same trees give the following radial widths of their principal parts:

TABLE IV.

Axes		Outer bark Epidermis and periderm	Middle bark Primary cortex	Inner bark Secondary cortex	Wood	Pith
One year old	Terminal	166μ 132 220	1348μ 1494 1245	83μ 96 90	249μ 192 288	1520μ 1610 1411
	Lateral	160 249 144	830 736 256	85 84 64	224 272 119	720 800 324
Two years old	Terminal	260 224 230	970 980 846	240 250 215	1040 1318 1246	1440 1250 1373
	Lateral	256 225 210	800 384 348	140 128 123	640 280 394	560 420 390

From the second year on this increased growth of the wood and secondary cortex of the main axes over that of the lateral branches continues.

Outer bark.—The terminal shoots have no epidermal hairs. The epidermis, however, of the one year old lateral shoots has numerous short, one to five-celled hairs,[22] the cells of which soon become thick walled. The cells are usually unequally thickened and pitted (*fig. 11*). The epidermal hairs of the lateral branches thus differ from the marginal hairs of the bud scales, which remain thin walled. Since the epidermal hairs

[22] Compare Tubeuf, *ibid.*, p. 35.

soon dry up and fall off, they are seldom found on two-year old or older internodes.

The cuticle is less developed than the cuticle of the leaves. The epidermal cells are thickened more on their outer than inner walls. The periderm or corky layer of the outer bark of the one year old shoots is composed of from 4 to 6 rows of cells, but through the activity of the cork cambium more layers are formed the second and following years. *A. balsamea* forms cork scales only after reaching a certain age. Thus one usually finds trees 20 to 50 years old with a smooth bark and without any distinct cork scales. The original epidermis is still present and can be peeled off in small scale-like layers.

Primary cortex (*middle bark*).—The outer part of the primary cortex, or middle bark, beneath the peridermal layers, is composed of from 4 to 6 strengthening collenchyma cells. The greater part of the chlorophyll parenchyma remains thin walled during the first year. Many of the cells, however, become thick walled and sclerenchymatous. This thickening of the parenchyma and differentiation into mechanical tissue continues during the second and following years. The sclerenchyma cells soon form short branches, the cell lumen of the original cell extending into them, giving them the appearance of branching bast fibers. Hartmann[23] calls these cells in *A. pectinata* bast fibers. That they are not bast fibers is shown by their parenchymatic origin and profuse branching. Their cell walls are laminated and pitted. They are usually aggregated together in nests of from 3 to 10 cells, forming areas of mechanical tissue.

Many of the parenchyma cells of the primary cortex function as secretion reservoirs for tannin and mucilage. Crystals of calcium oxalate are seldom found in the primary cortex. The tannin cells are scattered over the whole primary cortex, and do not vary in size and form from the chlorophyll parenchyma cells. The mucilage cells are spherical, ovoid, or elliptical, and vary in diameter from 30 to 240μ. The largest ones are

[23] *Ibid.*, p. 27.

found in the primary cortex of the older branches. They increase in size by the distention of their cell walls; consequently the larger mucilage cells are thinner walled.

The resin canals are always lined with one layer of epithelial cells. Surrounding this layer there are always present one or two layers of collenchymatic strengthening cells. No resin canals are formed after the first year, and during the first year only in the meristem tissue of the developing shoot, where they reach their definite size as soon as the tissue differentiation has taken place. After the resin canal has reached its definite size, the epithelial lining probably loses its resin secreting function; but its cells still remain thin walled and are able to divide, like ordinary parenchyma cells.

It is evident that with the increase in the diameter of the main axis and the peripheral growth of the bark, disturbances must occur in the resin canals of the primary cortex. As has already been stated, the primary cortex of *A. balsamea* remains alive, and is not thrown off by the formation of cork scales before the tree stems are from 50 to 100 years old. With the increase of the peripheral growth of the tree trunk, however, the resin canals are often disturbed by the cork cambium, which at places penetrates deeper into the primary cortex. Mayr[24] has demonstrated that as soon as a resin canal comes in contact with the cork cambium, the canal is filled up by the ingrowing of its epithelial cells, forming the so-called tyloses. In the development of each internode, a new system of resin canals is formed in the primary cortex, so that the canals of one internode do not connect with the canals of the adjoining internodes. The canals are always filled with an oleo-resin, so long as the formation of cork has created no disturbance in the turgescence by the loss of water from the cells surrounding the resin canals. The main resin canals are vertical and traverse the whole length of the internode. In older stems they are not always vertical, since the peripheral growth of the bark and main axis is not always

[24] MAYR, H.: Harz der Nadelhölzer; seine Entstehung, Vertheilung, Bedeutung und Gewinnung 21. 1894.

symmetrical. A part of the primary cortex, and with it the resin canals, may be cut off by the cork cambium. This may be only local, or include only a part of the resin canal. The part of the canal thus disturbed is soon filled by the ingrowing epithelial cells. It is evident that, with the intrusion of the epithelial cells, the resin is pressed into the undisturbed part of the canal, causing this part to distend and increase in size, by the radial and tangential division of its epithelial lining (*fig. 10, b* and *c*). In this way resin vesicles are formed, often two or more in each canal. Other factors besides the disturbances due to the cork cambium may cause tylosis; thus great temperature variations of exposed and shaded sides of the stem, and with it variations in the transpiration of the bark. Tylosis begins in the resin canal as soon as the loss of water from the cells and cell walls reaches a certain per cent. With the filling up of the resin canal the radial and tangential division of the epithelial cells of the resin vesicle still continues, and with it the vesicle increases in size, receiving at the same time all or nearly all of the resin of the original canal. Not only do the resin vesicles contain all the resin of the canal, but also the resin which is all the time being secreted by the tissues of the primary and secondary cortex. The great quantity of resin secreted by *A. balsamea* tends also to form the vesicles, as they begin to form even in four-year old internodes, and before tylosis has begun. With the increase in age of the bark the vesicles increase in size, so that in trees 20 to 100 years old the trunk of the tree always contains the balsam vesicles in great numbers. The larger ones are always found on the lower part of the tree trunk. They can be seen on the outside, where they appear as swellings or blisters on the bark. The periderm and outer part of the primary cortex give way to the pressure of the vesicle as it increases in size by the radial and tangential division of its lining cells. With the increase in size of the vesicle it becomes surrounded by several layers of cells resulting from the division of the epithelial lining cells. These become thick walled and soon break away from the surrounding tissues of the cortex, so that older vesicles

can be detached (*figs. 12* and *13*, *e*). Cross sections of one of these vesicles shows an inner thin walled layer of cells (*fig. 13*, *s*), surrounded by 4 to 10 layers of strengthing cells, which are elongated or stretched in the peripheral direction (*fig. 13*, *d*).

Secondary cortex (*inner bark*).—The medullary rays of the secondary cortex are composed of starch and protein conducting cells. The protein conducting cells are best seen in radial sections, where they form one layer on each side of the medullary ray. They are analogous to the protein conducting bast parenchyma of many conifers. The starch conducting cells occupy the central part of the ray.

The bast parenchyma cells are placed end to end in single isolated rows. Their cells are about 2 to 3 times as long as wide. The greater number are secretion reservoirs for tannin and calcium oxalate. Usually only one peripheral row of bast parenchyma cells is formed each year.

Bast fibers are absent in species of Abies and in the Abietineæ Many of the bast parenchyma cells become thickened and sclerenchymatic. Like the sclerenchyma cells of the primary cortex they often branch. They are usually found in groups or nests extending the whole length of the internode.

The remaining and by far the greater portion of the secondary cortex is made up of the sieve tubes. They are arranged in radial rows and, as in all conifers, have their sieve plates on their lateral walls. No vertical or horizontal resin canals are present.

Wood.—The medullary rays are composed of starch conducting or normal pith cells only. The protein conducting cells present in the rays of the secondary cortex are wanting. As in all conifers, the tracheids of the spring wood have larger lumina than the tracheids of the fall wood. No resin canals are present in the normal wood.

Pith.—The pith adjoining the pith septum on its under side differs from the internodal pith in that it is composed of a mass of loose cells, which break away from the septum, so that in two-year old and older internodes a cavity is formed immedi-

ately below the pith diaphragm. The greater number of these cells remain thin walled. Isolated cells often become thickened but not sclerenchymatic.

The internodal pith is made up of thin walled parenchyma cells and areas of sclerenchyma. The parenchyma cells are from 2 to 4 times as long as wide. They are polygonal in cross sections and rectangular in longitudinal sections. Isolated parenchyma cells often become thick walled in older internodes. The sclerenchyma cells are cubical and smaller than the parenchyma cells. They are provided with pore canals, and the thickening often extends inward so that the whole cell lumen disappears. The cells are arranged in definite areas extending from the periphery of the pith toward the center. Many of the sclerenchyma areas extend across the pith, thus forming a kind of diaphragm of mechanical tissue which alternates with areas of thin walled parenchyma.

2. *Diseased shoots and branches.*—The normal terminal shoots differ from the lateral, not only in that they are negatively geotropic, but also in the greater or less development of their different morphological units. The diseased shoots in many respects have characters similar to the normal terminal shoots. In comparing, therefore, the anatomy and morphology of the diseased shoots with the normal, the terminal shoots should also be considered. Hartmann[25] makes a comparison of the diseased with the lateral normal branches only of *A. pectinata.*

The affected branches, like the terminal, are negatively geotropic. Cross sections of the first year's shoots show a greater development of primary cortex and pith, while the secondary cortex and wood, in proportion to the former, are less developed, about the same as that of the lateral branches. In the second year of the diseased branches changes occur, which are more marked, especially in the increased growth of the periderm, wood and secondary cortex. The wood reaches its maximum growth during the second year. This is true of all the affected branches above the tumor. At the first point of infection the

[25] *Ibid.*, p. 35.

wood continues in its greater growth in width, producing the so-called boil or tumor. The growth in width of the secondary cortex of the tumor is greater than at any other part of the affected branches. The diseased branches have a greater diameter, but are shorter than the normal lateral branches. They have a reddish color, differing from the normal branches, which are yellowish brown. Although the diseased shoots are shorter, the number of leaves does not vary much from that of the normal.

Outer bark.—The epidermis does not vary much from the normal, except that epidermal hairs are rarely present. When present the hairs are usually only one-celled, agreeing in this respect with the terminal shoots, where epidermal hairs are absent.

The periderm is more developed. It consists of from 8 to 10 rows of cells the first year, which number is greatly increased during the second and later years, when the cork cambium gradually extends inward, and finally cuts off the primary cortex. In the tumor the cork cambium often extends as far as the secondary cortex during the first year of the infection. The cork cells are larger than the normal.

Primary cortex.—The cells of the collenchyma layer under the periderm are fewer in number, as well as less thickened. The chlorophyll parenchyma of the primary cortex contains no chlorophyll, but contains, at all seasons of the year, larger quantities of starch and tannin. More of the parenchyma cells become either thick walled or sclerenchymatous. The sclerenchyma cells branch more profusely, especially in the first year's shoot. The mucilage cells are smaller, as well as fewer, and do not increase in size with the increase in age of the branch. Fewer of the parenchyma cells contain crystals of calcium oxalate, but the number of tannin cells is greatly increased.

The resin canals are present in greater numbers, and vary more in their size and form, as well as in the number and size of their epithelial cells. The second layer of cells is less thickened. Since the growth of the periderm is greatly increased, and the formation of cork layers begins earlier in the affected

branches, even in the two-year old branches, it is evident that the resin canals are soon cut off by the cork cambium, and on drying become functionless. As in the normal, the resin canals are filled up by the ingrowing epithelial or surrounding parenchyma cells. This may occur in one part of the canal only, causing the formation of resin vesicles in the part where tylosis has not begun. The vesicles originate in the same way as in the normal, by the peripheral and tangential division of the parenchymatic lining of the resin canal. The resin vesicles begin to form even in the first and second year diseased shoots, increasing in size, so that in five-year old branches vesicles or blisters are found 3 to 8^{mm} in diameter. In five-year old normal branches vesicles are seldom found more than 1^{mm} in diameter. The increase in size and number, as well as the earlier formation of the resin vesicles of the affected branches, is due mainly to the earlier formation of cork layers and the greater resin secretion. On account of the increased growth of the bark of the tumor, the witch broom vesicles not only reach their largest size here, but they dry up and become functionless sooner than in any other of the diseased branches above the tumor. Since the primary cortex of the tumor is earlier affected, dries up, and is cut off by cork layers, the resin canal communication between the diseased branches above, and the normal branch below the tumor, is cut off or closed, even during the first or second year of the infection.

Secondary cortex.—The secondary cortex contains fewer sieve tubes, which are also smaller, often only one-half as long and broad as the normal. The radial walls are provided with fewer sieve plates. The sieve plates vary in size, but are usually smaller and more irregularly distributed. Fewer branching, bast fiber-like, sclerenchyma cells are present than in the normal. The protein conducting cells of the medullary rays are absent in the diseased bast of *Abies balsamea*. The bast parenchyma cells are larger and more numerous, and are usually filled with calcium oxalate and tannin.

Wood.—The growth of the wood in the diseased annual rings

does not vary greatly from that of the normal. The width of the wood cylinder in one year shoots above the tumor is about equal to that of the normal. The second, third, and fourth rings, however, are wider than the normal. The tracheids of the diseased wood are thicker walled. The annual rings of the affected branches are always more irregular in their width, and are often ten times as wide on one side as on the other. This may occur in one ring only, the following or preceding rings being equally thickened throughout. This unequal radial width of some rings is due to disturbances in the direction of the growth of the shoot that year. On account of the increased growth of the wood and bark, as well as the increased number of branches, the weight of the witch broom increases with its age, and more rapidly than the normal branches. The growth of the healthy part of the witch broom branch below the tumor is also less than in the normal ones. This part of the branch is, therefore, less able to bear the weight of the heavier affected part, and the witch broom becomes suspended, changing its position or falling on one side. The affected branches, which are all negatively geotropic, assume during the next season their erect growth by curving upward. On the convex side thus formed there occurs an increased growth, not only in the width of the annual ring, but the tracheids are thicker walled, rounded, and are separated by intercellular spaces, characteristic of all regulatory tissue formed in the wood of coniferous trees as a result of resistance to mechanical forces.[26] Although the annual rings in the affected branches are as wide and often wider than the normal, they still contain fewer tracheids per square unit of surface area. This is due to the fact that in the diseased branches more medullary rays are formed, often twice the number that are formed in the normal wood.

Resin canals, which are absent in the normal wood of *A. balsamea*, are always present in the wood of the tumor, and are nearly always present in the wood of older diseased branches

[26] HARTIG, R.: Den anatomischen Bau des Rothholzes. Forst.-naturw. Zeitsch. —: 163. 1896.

TABLE V.

SHOWING NUMBER AND DISTRIBUTION OF THE VERTICAL RESIN CANALS IN THE DISEASED WOOD OF A. BALSAMEA.

	Cross sections	Number of resin canals in annual rings. Annual rings arranged from bark toward pith[27]																						Diameter of resin canals μ	Remarks
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22		
Healthy part below the tumor.	I. 6cm below the base of the tumor.																								No resin canals present.
	II. 1cm below the base of the tumor.																								
Boil or tumor.	III. At the base of the tumor.	11	40	5																				12–25	Mostly endings of resin canals.
	IV. 1cm above the base of the tumor.	40	56	53	49	30	27	21	2															16–56	Canals usually found in the spring wood. The peripheral rings of the tumor are narrower and contain fewer canals. With the increase in age of the tumor there is a corresponding decrease in the number of resin canals of the annual rings; but with the increase in age of the diseased branches an increase in the number of resin canals formed takes place.
	V. 4cm above the base of the tumor.	18	30	39	47	84	111	104	120	105	95	58												21–55	
	VI. Middle of the tumor.	10	17	13	8	11	15	21	30	45	60	44	25	26	60	77	58	47	15	8[28]				24–60	
	VII. 1cm below the apex of the tumor.	9	6	17	30	56	50	36	28	15	11	8	6											18–50	
Diseased branches growing from the tumor.	VIII. Base of an 18-year-old branch.					4		6	19	21	26	4	3	2	5	4									
	IX. 4cm above base of branch VIII.							9	13	18	11	6	8		5	6									
	X. 10cm above base of branch VIII.						7	10	16	4	7	5		8	10	9									
	XI. 20cm above base of branch VIII.	14	11	8	4																			10–35	
	XII. 1cm above base of a side shoot of branch VIII.					8	4	12	9	8	11	6	4	3	5										
	XIII. 10cm above base of shoot XII.																								
	XIV. 9-year-old branch 40cm above tumor.					3	5	4						5	8										

[27] By arranging the annual rings from the bark toward the pith all rings that grew the same year will fall in the same column.

[28] Year of the infection.

TABLE VI.

SHOWING NUMBER AND DISTRIBUTION OF THE VERTICAL RESIN CANALS IN THE DISEASED WOOD OF A. BALSAMEA.

Witch broom	Cross sections	Number of resin canals in the annual rings. Annual rings arranged from bark toward pith												Diameter of resin canals μ	Remarks
		1	2	3	4	5	6	7	8	9	10	11	12		
A.—With 21 diseased branches growing from an area of about 6 sq. cm. of the tumor.	I. Healthy branch 4^{cm} below base of tumor.														No resin canals present.
	II. At the base of the tumor.	4	19											10–40	Endings of resin canals.
	III. 1^{cm} above the base of the tumor.	20	25	15	30	12	18[29]							11–45	Mostly endings of resin canals.
	IV. Base of a 6-year old branch from tumor.														No resin canals present.
	V. 3^{cm} above the base of branch IV.														No resin canals present.
	VI. 10^{cm} above the base of branch IV.														No resin canals present.
	VII. 20^{cm} above the base of branch IV.														No resin canals present.
	VIII. 40^{cm} above base of lateral branch of branch IV.														No resin canals present.
B.—Growing from the top of the main axis of the affected tree.	I. Healthy part 12^{cm} below base of tumor.														No resin canals present.
	II. Base of tumor.	7												8–37	Mostly endings of canals.
	III. 2^{cm} above base of tumor.	10	16	9		4			3		4			10–40	Many of them are endings of the tumor canals.
	IV. Base of a 3-year old branch from tumor.														No canals present.
	V. Base of a 6-year old branch from tumor.														No canals present.
	VI. 4^{cm} above base of branch V.														No canals present.

[29] Year of the infection.

above the tumor. The distribution and number of resin canals are given in tables V and VI.

Resin canals are never found in the healthy part of the branch below the tumor. They first appear in sections made at the base of the tumor and here only in the outer annual rings. All the resin canals of the tumor have their endings at the base, between the healthy and the diseased wood. The ends are pointed and gradually disappear between four tracheids, which in their meristematic condition probably functioned as epithelial cells. In sections made above the base of the tumor, the number of annual rings affected as well as the number of canals increases. The greatest number is found in the middle of the tumor (table V, section VI), where the canals, also reach their greatest diameter. From the middle of the tumor toward its apex the number of canals decreases, the greater number of them ending at its upper end. Many of the canals continue in the affected branches for some distance. The affected branches of some witch brooms have no canals (table VI, A., sections IV to VIII.)

Usually, however, with the increase in age of the branch, there is a corresponding increase in the number of its canals. With the increase in age of the witch broom the outer annual rings of the tumor and branches become narrower, often having only a few layers of tracheids. With this decrease in width of the annual rings, there is a corresponding decrease in the number of canals formed in the tumor; but an increase occurs in the number of canals formed in the branches (table V, sections VI and XII to XIV).

The resin canals are usually found in the spring wood, where they form a ring of canals separated only by the medullary rays (*fig. 14*). This ring of canals sometimes extends the whole distance around the annual ring. Usually, however, it extends only one-fourth to one-half of the distance, with here and there an isolated canal. Rings of canals and isolated canals are often found in the summer and fall wood. The regulatory tissue, or so-called "red wood," formed on the

convex side of recurving branches, seldom contains any resin canals.

Pith.—The diseased pith differs essentially from the normal in that its cells become thickened sooner, also forming larger groups of sclerenchyma cells. The cells of the pith area below the pith septum, which remain thin walled in the normal branches, become thickened in the diseased branches. Small areas of sclerenchyma cells are sometimes formed, which are never present in the normal. The internodal pith shows a greater development of mechanical tissue than in the normal branches. The diseased branches, which are correspondingly larger than the normal, also have a greater development of pith.

SUMMARY OF THE MOST IMPORTANT CONCLUSIONS.

Normal organs.

1. Stomata are found in greater numbers toward the tips and on the lower surfaces of the leaves of the lateral shoots. The leaves of the terminal shoots have their stomata distributed about equally on all sides.

2. Hypodermal strengthening cells are always present in the leaves. They are seldom found in cross sections made above the middle of the leaves of the lateral branches. Below the middle they are usually found isolated on the upper leaf surface and in continuous layers on the lower surface. The shorter, rigid, and terete leaves of the terminal shoots have a greater development of hypoderm.

3. The number of hypodermal strengthening cells decreases from the base toward the tip of the leaf; but with the decrease in the number of hypodermal cells there occurs a corresponding increase in the number of stomata.

4. The transfusion tissue is not as well developed in the leaves of the lateral branches as in the leaves of the terminal shoots. In the former there are two small areas, each one lying dorsal to the outer half of the two phloem areas. In the leaves of the terminal shoots the two transfusion tissue areas have

united and formed one large area on the dorsal side of the phloem and pericycle beneath the endodermis.

5. No epidermal hairs are present on the bud scales. All the scales are fringed with thin walled, hypha-like, marginal hairs, through which the resin diffuses to the exterior of the scales, until the bud is covered with a layer of resin sufficiently thick to prevent any further transpiration of moisture and exudation of resin.

6. Resin canals are usually present in all of the bud scales. Cross sections of many scales show from two to six resin canals.

7. The terminal or leader shoots, have no epidermal hairs. Epidermal hairs are present only on the one to three-year old lateral shoots.

8. Resin vesicles or blisters are formed only in the primary cortex and in those parts of the original resin canals which have not been disturbed by the unequal peripheral growth of the bark, cork cambium, and the formation of tyloses. The vesicles originate and increase in size by the radial and tangential division of the lining cells of the undisturbed part of the resin canal.

9. The normal wood of *A. balsamea* contains no resin canals.

Diseased organs.

10. Fewer stomata are present on the diseased leaves, and their distribution is similar to that of the normal.

11. Hypodermal strengthening cells are present, especially in the basal half of the leaf; they are more irregular in their form and size; and are often found in nests and groups.

12. The transfusion tissue is nearly always present, often in one to three small areas on the dorsal side of the phloem. The cells of the diseased transfusion tissue usually have simple as well as bordered pits.

13. The diseased buds are covered over with a greater number of bud scales, which are smaller than the normal. The diseased scales, like the normal, are fringed with marginal hairs and the buds are resin covered in winter.

14. Fewer of the diseased scales have resin canals; more than two canals are never present.

15. Epidermal hairs are rarely present on the diseased shoots. When present they are usually only one-celled.

16. Resin vesicles begin to form even in the first and second year diseased shoots. They increase in size so that in five-year old branches vesicles or blisters are found 3 to 8^{mm} in diameter. In five-year old normal branches vesicles are never found more than 1^{mm} in diameter.

17. Resin canals are always present in the wood of the tumor, and are nearly always present in the wood of older diseased branches above the tumor. The canals are usually found in the spring wood. With the increase in age of the tumor, there is a corresponding decrease in the number of resin canals of the annual rings, but with the increase in age of the diseased branches an increase in the number of resin canals of the annual rings takes place.

In conclusion, I wish to state that I am indebted to Director William Trelease and to the other officers of the Missouri Botanical Gardens for the use of their libraries and laboratories, and for kindly supplying facilities which have made it possible to do the work here presented.

MISSOURI BOTANICAL GARDEN.

EXPLANATION OF PLATES XIV AND XV.

FIG. 1. Cross section of a normal leaf 4^{mm} above its base, showing epidermal and hypodermal cells.

FIG. 2. Cross section of a normal leaf, showing the non-pitted, lignified parenchyma of the pericycle, bounded on its dorsal side by the endodermis.

FIG. 3. Cross section of a normal leaf, showing one of the two areas of transfusion tissue.

FIG. 4. Cross section of a diseased leaf, 4^{mm} above its base, showing the epidermal and hypodermal cells.

FIG. 5. Cross section of a diseased leaf, showing two areas of transfusion tissue: *a*, non-pitted, lignified parenchyma; *b*, bordered pits; *s*, simple pits.

FIG. 6. Section of diseased leaf, showing non-pitted, lignified parenchyma. Same magnification as in *fig. 2*.

FIG. 7. One of the outer and exposed normal bud scales, fringed with the marginal hairs, which are thin walled and filled with resin.

FIG. 8. Cross section of a normal bud scale with four resin canals.

FIG. 9. Cross section of a normal bud scale with two resin canals.

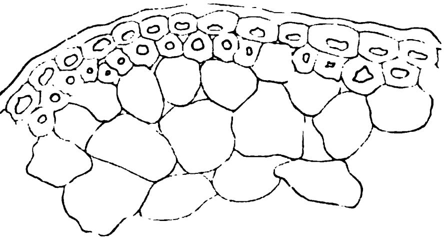
FIG. 10. Longitudinal section at the base of a bud of a normal shoot: *a*, cambium, with phloem and xylem cells; *b*, base of the annulus, or wall of the cup, surrounding the growing point in winter; *c*, base of the inner bud scales, composed of thick walled collenchymatous cells, similar to those of the annulus and pith septum; *d*, parenchyma of the primary cortex; *e*, part of pith septum, with irregular 3–4-sided prismatic cells; *f*, pith cells; *g*, loosely connected rounded pith cells, which break away from the septum in older internodes, forming the pith chamber.

FIG. 11. Epidermal hairs on a normal one year old lateral shoot.

FIG. 12. One of the detached resin vesicles of the primary cortex, magnified about four diameters: *a*, remnant of the original resin canal from which the resin vesicle developed.

FIG. 13. Cross section of the thin membrane covering the resin vesicle: *a*, thick walled, elongated or stretched cells of the membrane; *s*, thin walled epithelial cells lining the membrane of the vesicle on the inside; *b*, one of the epithelial cells dividing radially; *c*, one of the epithelial cells dividing tangentially; *d*, primary cortex; *e*, parenchyma cells of the primary cortex torn loose from the resin vesicle membrane, which has elongated or increased in size peripherally.

FIG. 14. Cross section of the wood of a diseased branch about 1^{cm} below the middle of the tumor, showing two abnormal vertical resin canals: *a*, an in-grown epithelial cell, filling up almost the entire lumen of the resin canal (tylosis).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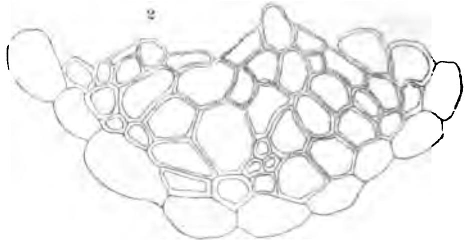
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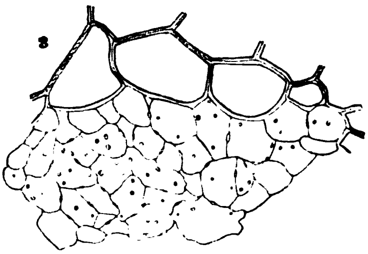
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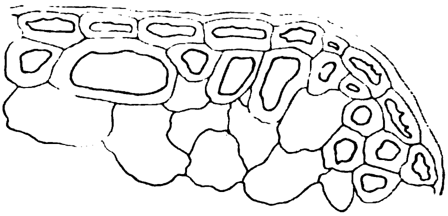
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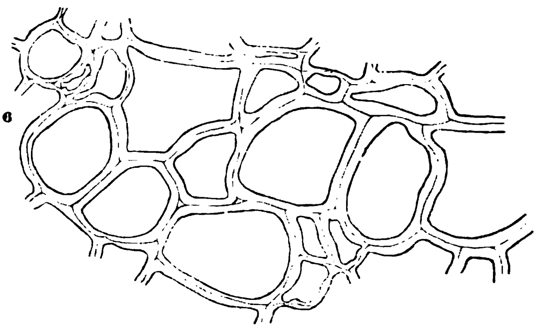
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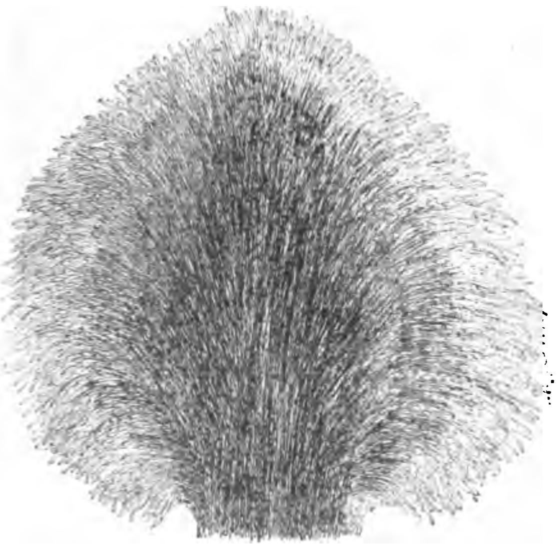
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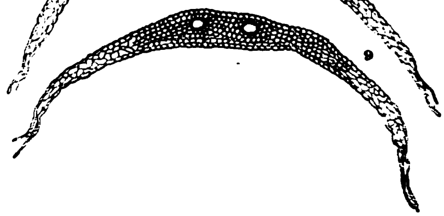
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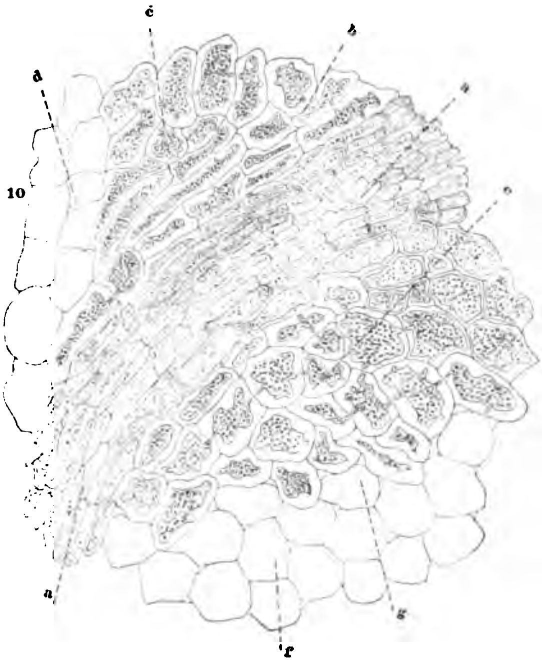
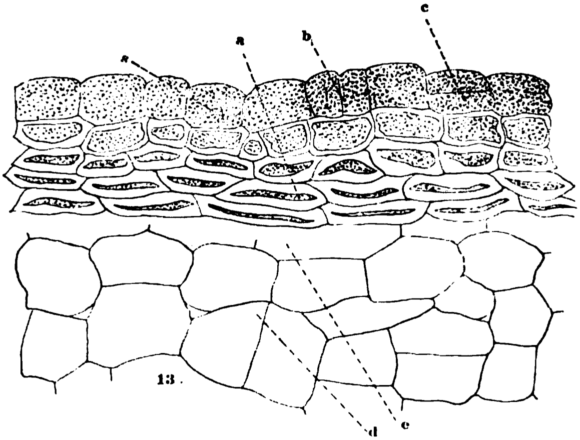
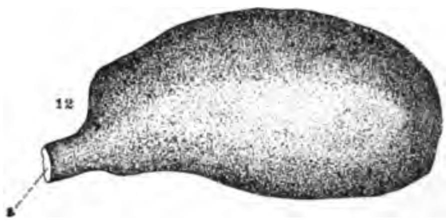
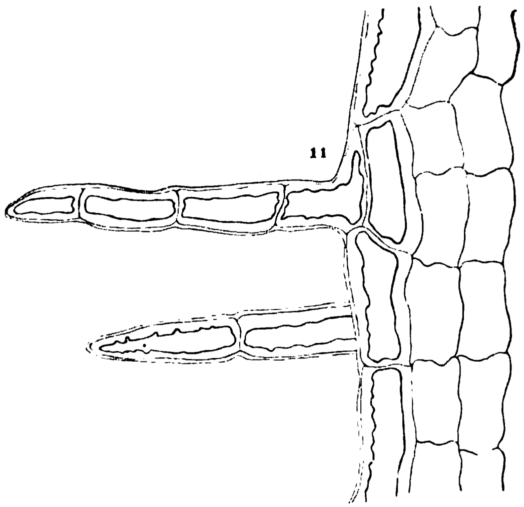
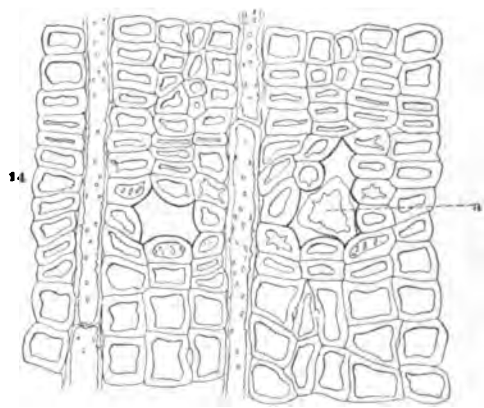










ANDERSON on ABIES AFFECTED by ÆCIDIUM.

THE PUBLIC GARDENS AND PLANTATIONS OF JAMAICA.[1]

WILLIAM FAWCETT.

INTRODUCTION.

JAMAICA is about ninety miles south of Cuba. Its most western point is nearly directly south of Toronto, as it lies between 78° 20′ 50″ and 76° 11′ W. long. It is situated between 18° 32′ and 17° 43′ N. lat., so that it is only one to two degrees nearer the equator than the City of Mexico (19° 25′), and a little farther from the equator than Belize. It is a very small island, being only 144 miles long and forty-nine miles wide in its broadest part; its area amounts only to 4,207 square miles, of which very little is flat, and a great deal is not suitable for cultivation.

The aboriginal name of Jamaica was Xaymaca, denoting "a land covered with wood, and watered by shaded rivulets." The character expressed by the name is what one might expect to find in an island with lofty mountains, its shores bathed by the Gulf stream, and lying in the path of the trade winds. The general trend of the mountain ranges being at an angle to the direction of the prevailing winds, there is considerable precipitation nearly all the year round in some parts, while in other districts a small amount of rain falls during a few days only in two months of the year.

The general features of the landscape and of the flora which clothes it have been developed by the position of the island, and its geological history. The lowest strata containing fossils are the Hippurite limestone of the Cretaceous series. Below this there is a series of metamorphosed shale, sandstone and conglomerate, with dikes of intrusive diorite, syenite and granite.

[1] Prepared for the Botanical Society of America, Toronto meeting.

Above the Hippurite limestone are beds of black shale, 1000 feet in thickness, overlaid by a trappean series, all of which are placed by Sawkins in the Eocene age. Then follow the yellow limestone of Miocene times, white limestone of very recent age, and marl, coast lime, and alluvium of post Tertiary times.

The differences in elevation from sea level to the 7423 feet of the Peak, the various exposures to sunlight, the abundance or the want of rain and dew, the geological formations, all have their influences on plant life, and make the conditions of existence of the most diversified character, and the cultivation of economic plants from all parts of the world an easier task than in most other places.

HISTORY OF THE GARDENS.

The first botanic garden in Jamaica was formed about 150 years ago by a private individual, Mr. Hinton East, on his property near the present village of Gordon Town, nine miles from Kingston. After it had been in existence for some years, in 1774 Sir Basil Keith became governor, and determined on the formation of two government botanic gardens, one a "European garden," and the other a "Tropical garden." In December of the same year a committee of the legislature recommended that £700 be appropiated for the purchase of a piece of land proper for a botanic garden, and that £300 sterling be provided for the annual salary of a botanist.

In 1775 a property named Endfield, adjoining Mr. East's garden, was purchased and Dr. Thomas Clarke came out "at the particular instance and request" of Sir Basil Keith, as island botanist, and to take charge of the gardens. Dr. Clarke introduced in 1775 the China tea plant, camphor, litchi, *Cycas circinalis* (the "sago palm"), and *Desmodium gyrans*; in 1778 *Blighia sapida* (Akee); and in 1779 the clove tree. Endfield being a "steep hillside" proved unsuitable, and in 1778 a law was passed to purchase land for a botanic garden at or near Bath. The botanic garden at Bath was founded in 1779 and placed under the care of Dr. Thomas Clarke.

In June 1782 Captain Marshall, of H. M. S. Flora, one of Lord Rodney's squadron, captured a French ship bound from Mauritius for Haiti, carrying a number of plants of economic value. The ship was sent as a prize to Jamaica, and Captain Marshall "with Lord Rodney's approbation" deposited the whole collection in Mr. East's garden. Many plants were new introductions, and amongst these were the mango, cinnamon, and jack fruit.

2 On Mr. East's death in 1790, the Liguanea garden was offered by his nephew to the assembly as a public garden at their own price. It was purchased under the authority of an act of the Assembly, the preamble stating that the garden in Bath was insufficient in extent, and was besides liable to be carried away by the river which had destroyed two-thirds of the town.

In 1793 Captain Bligh in H. M. S. Providence brought several hundred plants of the breadfruit and other valuable plants from Otaheite for the West Indies. These were distributed to the gardens at Liguanea and Bath, and to other centers, and committees were appointed to make arrangements for their reception, the care of them, and their distribution. One of the gardeners, James Wiles, who had circumnavigated the globe with Captain Bligh, was appointed to the care of the Liguanea garden, and writing to Sir J. Banks in 1793, he says:

> All the trees under my charge are thriving with the greatest luxuriance. Some of the breadfruit are upwards of eleven feet high, and my success in cultivating them has exceeded my most sanguine expectations. The cinnamon tree is become very common, and mangoes are in such plenty as to be planted in the negro grounds.

In 1782 Dr. Thomas Dancer was elected physician of the Bath of St. Thomas the Apostle; in 1788 he was appointed by the legislature superintendent of the Bath garden; and in 1797 island botanist. The duties of the island botanist were defined as follows:

> To collect, class, and describe the native plants of the island; to use his endeavors to find out their medicinal virtues; to discover if they possess any qualities useful to the arts, and annually to furnish the House with a correct list of such plants as are in the botanic gardens, together with such information as he may have acquired relative to their uses and virtues.

In 1799 Dr. Dancer went to practice in Kingston. He made the medicinal plants of the island a special study, and published in 1801 "The medical assistant, or Jamaica practice of physic." He died in 1811.

The colony had now to undergo a period of difficulty and distress, as the slave trade was abolished in 1807 without compensation to the planters, and the wars with France and the United States caused great depression. Accordingly in 1810 the Liguanea garden was sold, and that at Bath was never afterwards adequately supported.

In 1825 Dr. Jas. MacFadyen was appointed island botanist. In 1837 appeared the first volume of his *Flora of Jamaica*; in 1850 part of the second volume was printed, and this was all that was published. He did not retain his appointment long; and in 1828 Thomas Higson was appointed island botanist and curator of the botanic garden at Bath. He presented to the garden a collection of living plants collected by himself in South America.

In 1829 the garden at Bath, of one and three-fourths acres, was increased by three acres to the west. Higson left Bath in 1832; and in 1846 Nathaniel Wilson was appointed island botanist with the care of Bath garden. Wilson had been in the gardens at Kew and at Kensington for several years, and was a most capable man. He kept up a correspondence with Sir W. J. Hooker, director of Kew gardens, and introduced a very large number of plants from Kew and other parts of the world, trusting to be repaid his expenditure by the liberality of the assembly. *Bœhmeria nivea* was imported by him, and he formed a very extensive collection of fiber plants. He also received from Kew in 1846 and 1847 the mangosteen, litchi, durian, and *Musa Cavendishii*. In 1849–1850 he reports the arrival of Poinciana, Spathodea, *Bougainvillea spectabilis*, *Cæsalpinia Sappan*, Amherstia, and Assam tea.

In 1851 there was some intention of moving the site of the garden elsewhere, and Wilson, referring to Bath, says in his report for that year:

I would most unhesitatingly say that a more congenial climate for the growth and propagation of plants is not to be met with in the island. The humidity of the atmosphere is proverbial and suitable to a peculiar degree for plants in general.

In 1856 the Sulphur river inundated the garden for the fifth time since 1848 and destroyed half an acre. These floods and the impossibility of extending the garden for the growth of additional plants were constant difficulties with Wilson, and in 1858 he says:

The attention of the executive has of late been pointedly directed towards it [the garden] with a view not only to place the establishment on a scale of permanent efficiency, but in a more central locality, accessible from all parts of the island . . . . The want of a more central and extensive depot has long been felt, particularly at the west end and north side of the island, where distance renders it impracticable to convey plants safely, and where industrial institutions and experimental gardens are springing up.

In 1860 the legislature appropriated money for the purchase of Castleton, and Wilson was entrusted with the formation of a garden there, on the understanding, however, that the garden at Bath was to be maintained for supply of seeds to Castleton, and plants for general distribution. In his report for 1861, he states that Sir W. J. Hooker had sent out the previous year seeds of *Cinchona succirubra*, *C. nitida*, and *C. micrantha*, and that several hundred plants were ready for planting out. At this time the market price for succirubra bark was 6s. per lb. In 1862–63 an assistant to Mr. Wilson was appointed, Mr. Robert Thomson, and the formation of the garden at Castleton was commenced.

Experiments were made in planting out cinchona in different parts of the Blue mountains, and at length in 1868, during the governorship of Sir John Peter Grant, the cinchona plantations were started under Mr. Thomson as "superintendent of botanic gardens" in succession to Mr. Wilson.

Six hundred acres of virgin forest land were assigned for planting cinchona by Sir J. P. Grant on the southern slopes of the Blue mountains, ranging from 4000 to 6000 feet above sea level, and a commencement of work was made in the same year

(1868) by planting out forty acres with five species of cinchona. Now also a first beginning was about to be made to realize the conception of Sir Basil Keith of nearly a hundred years before to have a "European garden" in a temperate climate. A small plantation was made in 1869 of Assam tea, and afterwards of a hybrid between the Assam and China. *Eucalyptus globulus* from Australia, *Cupressus macrocarpa* and *Pinus insignis* from California, and *Pinus excelsa* from the Himalayas are among the forest trees planted out and flourishing in later years. In 1869, 40,000 plants of cinchona were offered for sale at rates of £5 to £7 per 1000.

At Castleton, up to 1869, there had been no general impor tation of plants, because of doubts about maintaining the garden on account of its distance from Kingston. In the Blue Book for 1871 Sir J. P. Grant says:

> The famous Jamaica botanic garden of ancient times, which was not only of the highest intrinsic value, but also was admirably situated, was sold, I believe, for a trifle, and was broken up a long time ago, in some spasmodic fit of false economy. More lately a botanic garden was established at Bath. The site was unfortunately selected, being a long day's journey from the capital. But the purchase, in 1859, of Castleton, and its formation in 1863 into a new botanic garden in substitution for the garden at Bath, which was finally abandoned in 1866, is said to have been determined upon because of serious damage caused and threatened by a water course. The selection of Castleton as the site of the new garden was also unfortunate, as it is a distance of nineteen miles from Kingston; and it is important to interest the public as much as possible in such an institution as a botanic garden. But the selection having been made, and a large number of plants having been established there, whilst the position, except in respect of its distance from the capital, is unexceptionable, it would have been unwise once more to have thrown away all that our predecessors had done for us by removal to a fourth position. It was determined therefore to treat the Castleton garden as a fixture; and as it is not too far from Kingston for a holiday excursion, to go to some little expense in its gradual embellishment, in the hope of attracting visitors to what I believe will certainly become one of the most interesting spots in the West Indies.

As soon as this determination had been arrived at in 1869, Dr. (now Sir) J. D. Hooker sent out from Kew great numbers of

new and valuable plants, 400 different species and varieties, among which were mangosteen, Brazil nut, bhel, *Monstera deliciosa*, carob bean, coca, Tonquin bean, teak, New Zealand flax, and thirty-two species of palms. In the same year two cases of grafted mangoes arrived from India *via* Kew; Mr. Thomson states that "to His Excellency the Governor, from his personal knowledge of Indian mangoes, we are obliged for their introduction." Even at this early period of its existence the nutmeg trees began to bear fruit, and the clove trees were six feet high.

In the same Blue Book quoted above, Sir J. P. Grant reports that a gardener had been obtained from Kew to reside at Castleton, as Mr. Thomson had taken up his residence at the cinchona plantations thirty-four miles off, in the Blue mountains. He took charge at Castleton in December 1870.

> Upwards of 200 species of plants new to the island were introduced during the year. Among these perhaps the most interesting were two plants of Ipecacuanha, two true mangosteens, and five choice varieties of pine apple; also four noted Bombay grafted mangoes, imported two years ago, are very flourishing, some of them being already five feet high. My belief is that there is nothing to prevent Jamaica becoming, for the quality, variety, and commercial value of its fruit, the most noted spot in the world, when gardening shall be understood, and the value of the art shall be duly recognized here.

In 1870, four varieties of orange were imported, viz., navel, St. Michaels, tangerine, and mandarin. In after years thousands of grafted plants of this St. Michaels, and seedlings also of the tangerine and mandarin were distributed all over the island. A large tank was made for the cultivation of the *Victoria regia*, which has been growing there ever since.

This was a period of great importance in the history of the development of the public gardens. In 1868 the government undertook to plant out in cocoanuts the narrow sandy strip of land, known as the Palisades, with Port Royal at one end, forming a natural breakwater for the magnificent harbor of Kingston. The first clearing and planting was done early in 1869, and by 1879 nearly 20,000 cocoanut palms had been planted out, and 700 of them were bearing fruit. In 1870, £1800 was voted for

the establishment of a garden in the Parade square of Kingston, and in 1871 £2267 were voted for continuation of the work. This sterile waste in the center of the city about seven acres in extent, Mr. Thomson reports in 1871, was enclosed with a handsome iron railing. In 1871 the governor ordered that:

In an appropriate quarter of the garden at Castleton space should be reserved for every species of cane procurable, so as, if possible, to afford specimens of every true, distinct, and permanent variety known. The botanical garden of Jamaica should not be behind any garden in the world in regard to specimens of this particular sort of plant.

The governor applied to Mauritius and Martinique for specimens of all varieties of cane grown there. Over sixty varieties of sugar cane were received in 1872 and 1873 from Mauritius, and the salangore from Martinique.

In Sir J. P. Grant's report in the Blue Book for 1871, published in the *Gazette*, October 1872, he says:

The Bombay grafted mangoes, planted three years ago, are in a thriving condition, and from eight to nine feet high. I do not doubt that the finest varieties of this almost unequalled fruit will thrive here quite as well as at Bombay. The plant has naturalized itself here in the course of only ninety years, and now spreads itself self-sown over large tracts in all parts of the island. As the propagation has been exclusively from seed, it is surprising to find amongst these wild trees so many bearing fruit at all eatable, which I think could not be the case were not the climate and soil very propitious for this plant. The quantity of fruit produced is remarkable, and it is greedily devoured by horses, cattle, and swine. With vessels running in six days to New York, the commercial value of an orchard of fine Bombay mangoes near Kingston would surely be very great.

Mr. Thomson in his report for 1873, referring to these mango trees, points out that:

Although the climate of Castleton is extremely favorable for the growth of these plants, the reverse is the case so far as the production of fruit is concerned. As soon as possible, however, a small plantation of these varieties will be established at the proposed garden at Hope, which, with its far drier climate, is probably as good a locality as any in the West Indies for the production of this fruit.

In 1873, the report of the gardens states:

Arrangements have been made to commence operations at Hope, with the view of establishing a pleasure garden and a small sugar cane farm for experimenting upon new varieties of canes. The climate of the Castleton garden is too humid for numerous species of plants, which will find a congenial home in the drier climate of the Liguanea. . . . . The establishment of this garden, simultaneously with that on the parade, coupled with the greatly increased command of water in the course of being brought to Kingston, must undoubtedly constitute a new era in the history of horticulture in Jamaica.

It was found advisable to secure the services of a skilled European gardener at Cinchona. Accordingly Mr. Nock arrived here in April 1874, from Kew gardens. He devoted attention to the cultivation of European vegetables, which he hoped to show may be successfully grown in great abundance and variety under our conditions of climate. Mr. Thomson says in 1875 that:

Mr. Nock has been very successful in producing an assortment of vegetables such as are not grown elsewhere in the island. It is to be hoped that the peasantry will initiate the cultivation of similar vegetables, as these experiments show that at this height (5000 feet above the sea) almost all European vegetables can be grown with advantage.

These hopes have been fulfilled, for the peasantry now grow all kinds of "English" vegetables in the Hill gardens district.

In 1876 a plantation of Liberian coffee was established at Castleton. With reference to the "Hope experimental grounds," Mr. Thompson wrote:

It is about three years since the government obtained possession of upwards of 200 acres of Hope land, contiguous to, and for the most part under the level of the Hope reservoirs. The acquisition of this land afforded an excellent opportunity for experimenting upon the numerous new varieties of canes that had just been imported from the Mauritius botanic garden. While this matter was under consideration, it was also proposed that the beautifully situated land in question should be utilized in a variety of ways. Among other schemes it was proposed that, in consideration of the accessibility of this locality to Kingston, a pleasure garden should be formed for the inhabitants of that city.

But the want of water prevented anything more being done than planting out a few canes, and forming a small nursery.

The collection of new sugar canes, embracing some sixty varieties of new

canes, imported a few years ago from the Mauritius botanic garden, was in the first place established at Castleton garden. As the necessary scope and appliances at Castleton for the experimental cultivation of these canes on a sufficiently large scale were not obtainable, advantage was taken of the government land at Hope to carry out the necessary experiments. Accordingly in 1874 the first batch of canes, consisting of eighteen varieties, was transferred to Hope and planted to the extent of nearly an acre each. In 1875 the remaining varieties at Castleton, numbering upwards of forty, were removed to Hope, and there planted in small plots in order to ensure a command of cuttings for subsequent propagation, the area occupied by these being about five acres.

But water failed often and there was disappointment. Some fifty plants of teak were set out at Hope in 1874, and 500 plants more in 1875. About ten acres were thus planted with teak.

Mr. Thomson retired on pension in 1878, and in December 1879 the gardens and plantations were constituted a department under Mr. Daniel Morris as director. The management of the gardens and grounds attached to Kings house, the residence of the governor, was now placed under the department. Dr. Morris, in his report for 1885, refers to the future development of Hope nurseries.

The only drawback to this locality as a site of a botanic garden is the smallness and precarious nature of the water supply. . . . . Although sufficient for the nursuries this water supply is wholly inadequate to maintain a large area, such as a botanic garden must necessarily be, under perpetual cultivation, unless a system of reservoirs and tanks were introduced for the storage of water.

The Hope plantation might, however, be greatly extended in the direction of growing and distributing economic plants, and in this respect the establishment would prove of great service to the island. As circumstances permit, this work will be transferred as much as possible from Castleton, leaving the latter to supply only the districts in communication with the main trunk road and the north side.

The lands adjoining the Hope nurseries, about 100 acres in extent, might be cleared and laid out as a public park, with grass lawns and shade trees, and afford a convenient and healthful resort for the inhabitants of Kingston and Half Way Tree. At present, persons driving along any of the hot, dusty, and dreary looking roads leading out of Kingston have no place where they could get out of their carriages and enjoy a walk under shade. With the exception of the Parade garden, Kingston, which is largely fre-

quented by the poorer classes of people residing in the immediate vicinity, there is no place of the nature of a park in the island. In the neighborhood of every tropical city it is very necessary to have a public park provided with seats and ample shade trees where the people can for a time, at least, escape from the heat, and glare, and dust, and where they come into contact with some of the fresh invigorating influences of nature.

The cost of laying out a park at Hope in conjunction with the experimental cultivation of fruit trees and nurseries of economic plants would be about £4,000 to £5,000.

The governor, Sir Henry Norman, commenting upon this view of the future of Hope, wrote:

As regards the Castleton and Hope nursery gardens, it will be seen that there is a tendency rather to increase the usefulness of the latter than the former, and considering the inconvenient situation of Castleton this seems right. Measures may be taken from time to time to improve the Hope gardens, but I am not prepared to recommend outlay from public funds for the construction of a park at the Hope. It is situated five miles from Kingston, which is too great a distance to allow of the poorer classes of the population enjoying the benefits of the proposed park.

The scheme proposed now to connect Kingston and Hope gardens by an electric tramway with cheap fares removes the objection that the poorer classes of Kingston would not be able to make use of it.

Dr. Morris left Jamaica in March 1886 to take up an appointment as assistant director of Kew gardens. Sir H. Norman then referred to a committee of the legislature the consideration of the condition of the department, and the provision to be made for its maintenance in the future. The committee submitted a report, which was adopted by the council in October 1886. In it the committee state that they

Fully recognize the importance to a purely agricultural colony of an organized department for the giving of reliable and authoritative information in matters of agriculture and cultivation and for the dissemination of such knowledge. The importance of this is specially enhanced at the present time when the depressed condition of our staple products in the markets of the world suggests not only the application of all means of science and invention to their more perfect and more economical production, but also the encouragement of the cultivation of those so-called minor products for which

the soil and climate of this island are so fortunately suited. Courage may be taken from the experience of Ceylon, where the effects of the failure of its great staple of coffee have in a few years been largely diminished by attention to the cultivation of tea, cocoa, and other products, which has been materially benefited by the interest and fostering care of the botanical department of that island. The influence of a trained and scientific chief over such a department must be felt as well in the interchange and in the consequent continuous and careful thought of the information and experience of old and practical planters and cultivators, as in the education and training of the younger and inexperienced, and in the intelligent and profitable application of means and labor of both peasant and proprietor, to present and to new objects of cultivation.

The work of the gardens department, its chief aims and possibilities, have frequently been brought before the public of Jamaica in the present director's annual reports. Thus in 1892 occurs the following:

The two main divisions under which work in a colonial botanical department may be classed are: first, the supply of plants yielding products new to the agriculture of the colony, or of a better kind, or such as are not readily obtainable otherwise, involving experimental and nursery grounds in such situations as are suitable; second, the providing of information regarding the kind of soil, climate, etc., fitted for the plants, their proper cultivation and preparation for the markets. The second division is most economically and effectively carried on by means of printed matter combined with correspondence; but practical demonstrations of methods in the gardens are advisable whenever they can be carried out. Both divisions imply considerable correspondence with persons in other countries as well as a complete herbarium and a good library.

During the past twelve and one-half years, from the time that Mr. Morris was first made director, to March 31, 1892, about 220,000 plants have been distributed from Castleton alone, besides seeds which would produce at least as many plants. This gives an average for a year of 17,600 plants, and includes those sent to Hope for distribution from that center.

Of those plants, about half the number were such as may be termed strictly "economic," such as cocoa, nutmeg, cloves, cinnamon, Liberian coffee, vanilla, oranges, East Indian mangoes, cardamon, kola. The remainder were palms, roses, ferns, orchids, and miscellaneous trees and shrubs, among which are included timber trees.

I stated in my report for the year 1887–8 that although it was not the mission of a botanic garden to undertake the work of a horticultural establishment, and supply the public with ornamental plants, I thought it right to

do as much as possible in that direction, so long as there was no probability of interfering with private enterprise.

But the danger of interfering with trade seems remote, and the demands on the part of the public are positive and increasing. There has been an annual demand for some 8000 or 10,000 ornamental plants, and even more than the department can supply with its present means. The question may sometimes arise, is the government right in fostering this demand; is it a legitimate one; is some great end served by the necessary expenditure, and the attention to the numberless details that it implies?

It appears to me that the question only needs to be stated for all intelligent persons to answer in the affirmative. Bacon recognizes a love for gardening as an index of a nation's advance in civilization, and without doubt it is an important factor in rendering that advance more easy and more certain. He says (Essay 46), "God Almighty first planted a garden, and indeed it is the purest of human pleasures. It is the greatest refreshment to the spirits of man, without which buildings and palaces are but gross handiworks; and a man shall ever see, that where ages grow to civility and elegancy men come to build stately, sooner than to garden finely; as if gardening were the greater perfection."

The plants, cuttings, and seeds, both economical and ornamental, from Castleton as well as from the other gardens, are distributed all over the island by means of the coastal steamer, the railway, and the post office.

The increase in the variety of cultural products, and the humanizing influence of ornamental plants are matters of appreciation in every part of the country from the mountain to the seacoast. Every person who obtains plants and grows them, from the sugar planter who makes trial of different varieties of cane, to the small settler who grows a nutmeg plant, is making experiments which are of direct benefit to himself and indirectly to his neighbors and to the district.

Parochial or other associations can do a great deal to help the work by meeting periodically to discuss all matters connected with agriculture. The sympathy felt between those engaged in kindred pursuits, the feeling of rivalry aroused to attain better results, the mutual aid obtained by interchanging ideas, are all most valuable in the improvement of agriculture. He who undertakes the laborious task of starting such an association in his own district, though he may find few at first to join him, yet by perseverance with even only one or two sympathizers will eventually meet with his reward. Such an association and this department can render mutual assistance to each other in many ways with results that will be of general benefit to the whole island.[2]

The great importance of Castleton as a botanic garden over the other gar-

[2] The local association work has been undertaken by the Jamaica Agricultural Society, formed in 1895.

dens may be estimated from the fact that there are some plants such as vanilla, which will only grow naturally there, and that there are others, such as roses, which can only there be successfully propagated. Castleton must therefore always be the great propagating center.

It is scarcely necessary to say anything in Jamaica about the importance generally of botanic gardens, for the need for them has been continuously recognized there for more than one hundred years. The value of those existing in Jamaica, Trinidad, and Demerara, is so evident that lately botanic gardens have been started in Antigua, Dominica, Montserrat, and St. Kitts, Nevis, among the Leeward Islands; in Grenada, St. Lucia, and St. Vincent among the Windward Islands; and still more recently in British Honduras.

The same movement is also going on in other parts of the world; for instance, botanic gardens have lately been established in Lagos, and the Gold Coast on the west coast of Africa.

Botanic gardens in the tropics do the work on the plant side of agricultural departments in temperate climates. They are in themselves experimental stations; and are much more efficient in introducing new cultural products, and in distributing plants and imparting useful information, than most agricultural departments.

The whole of the botanic gardens in the British Empire are more or less in communication with one another, exchanging seeds, publications, etc., and all look up to the Royal gardens at Kew as to their head for advice and assistance. Imperial federation is already in existence as regards the botanic gardens and their work. If any special variety of a plant or any new culture comes into notice, information and plants are sought sometimes directly from the local gardens; sometimes through Kew as the botanic gardens' clearing house. The director of Kew gardens has at his disposal the services of experts in every branch of botanical inquiry, and is always most willing to aid colonial gardens in every way. Any intricate question that arises in chemistry, in diseases of plants, in insect pests, in the value of products, etc., can be determined by reference to Kew. Colonial gardens are therefore not isolated, but are branches of an agricultural department as wide as the British Empire itself.

In 1896 the following paragraphs are found:

Although the means and the number of men at my disposal are infinitely small, as compared with the resources at the command of the government of the United States, we try to follow at a very long distance the aims and the methods adopted by them. Dr. A. C. True, the director of the office of experiment stations in the United States, has lately given a lucid exposition of the objects and work of these stations, and an extract from his bulletin will very clearly illustrate what we should always be striving after here.

Then follow extracts showing what the objects of the stations are, and details of their work:

Chemical analysis and the study of live stock are outside the limits of our sphere at the gardens, but attention is paid to nearly all the other points detailed.

Dr. True continues:

The service which the stations have rendered in promoting the education of our farmers is incalculable. Even if the station bulletins recorded only facts well known to scientists and advanced agriculturists, the influence of such a far-reaching system of popular education in agriculture must be very great. So vast a scheme of university extension has never been undertaken in any other line. The stations have also taught the farmer how to help himself.

The *Jamaica Bulletin*, which was started in a small way in 1887, appearing at irregular intervals, has now increased to a publication of twenty-four pages, appearing regularly once a month. It is sent free by post to all who ask for it, and the circulation is steadily increasing. The department, indeed, takes in some respects a wider scope than the experiment stations of the United States, for not only are practical lectures given in various parts of the island, but an agricultural elementary school is managed under its auspices, and the boys are trained in practical work in the gardens.

PARADE GARDEN.

The Parade garden was formed for the recreation of the inhabitants of the city of Kingston, the principal port of the island and the seat of government. It is about seven acres in extent, with shady lawns, lily tanks, borders of ornamental plants, and numerous palms and tropical flowering trees. It is lighted in the evenings by electric light, and a military band performs once a week. Elevation, 60 feet; annual mean temperature, 79° F.; average rainfall, 34.73 inches.

KINGS HOUSE GARDEN.

The garden and grounds around Kings house, the residence of the governor, amount in extent to 177 acres. The avenue from the entrance gate to the house is formed of the willow fig (*Ficus benjamina*), and the royal palm (*Oreodoxa regia*), with borders of ornamental shrubs and creepers, such as crotons, Hibiscus,

Acalypha, Tabernæmontana, Mussaenda, Tinnea, Bambusa, Dracaena, Musa, Bignonia, Antigonon, Stephanotis. In the garden, adjoining the house, there are orchids, ferns, palms, climbers, and ornamental plants generally, with several lawns, and a tank for nymphæas and the *Victoria regia*. Elevation, 400 feet; annual mean temperature, 78.7° F.; average rainfall, 48.51 inches.

HOPE GARDEN.

Hope garden is situated in the Liguanea plain between five and six miles from Kingston at the base of the hilly country through which the road passes for ten miles or so to the Blue mountains. The plain of Liguanea is one of the dry districts, the average annual rainfall at Hope being only 51.5 inches. Vegetation is affected not only by the want of rain, but also by the sea breezes, which in their passage across the plain become quite dry. The plain is characterized by the presence of Cactaceæ, such as various species of Cereus and Opuntia. The trees include *Prosopis juliflora* (cashaw or the mesquite of the mainland), *Guiacum officinale* (lignum vitæ), *Parkinsonia aculeata* (Jerusalem thorn). As we approach Hope, at the base of the hills the rainfall increases, from 35 inches in Kingston, and *Catalpa longissima* (the yoke wood tree), and *Pithecolobium Saman* (the guango) occur, while the Cactaceæ disappear.

The character of the flora is affected also by the soil, which is alluvial without any admixture of clay. Where limestone rock commences on the hill called Long mountain, the prevailing feature is the beautiful yellow flowered *Agave Morrisii*. The soil of the plain is very fertile when irrigation can be used, and the gardens in fact form part of the old Hope sugar estate.

From being at first a small nursery and an experimental ground for sugar cane, it has now developed into a large garden with six acres of lawns, three and one-half acres of ornamental borders, also ferneries and orchid houses; collections of roses, crotons and palms; plantations covering seven and one-half acres of sugar cane, Arabian and Liberian coffee, oranges, ginger,

tobacco, ramie, and five or six acres of teak. It is hoped that in time it may be possible to make it a geographical botanic garden with different sections for India, Australia, China, etc. Two and one-half acres are given up to the nurseries which contain about 70,000 plants, such as cocoa, nutmeg, clove, orange, vanilla, cinnamon, Liberian coffee, rubber plants, etc. It is the distributing center, and on an average 40,000 plants are sent out all over the island each year. The director has a residence, office, library, and herbarium in the garden. Elevation 600 feet; annual mean temperature 74.4° F.; average rainfall 51.54 inches.

HILL GARDEN.

The following account of the possibilities for usefulness of the Hill garden was written by me eighteen months ago. The ceremony, by His Excellency the Governor, of cutting the first sod of the new driving roads along the southern slopes of the Blue mountain range, inaugurated a new era of prosperity for a wide stretch of country from Newcastle to the Cuna-cuna pass. The only means of communication, until quite lately, in all this region from one district to another and to the sea-coast road, was by bridle paths, a terror to nervous riders and impossible for invalids. The road connecting the plain of Liguanea with Gordon Town is so short that it scarcely counts when there is now a commencement of the construction of roads which are to be 100 miles in length. The only cultivation in these mountains on a large scale has been of coffee, and this industry has been seriously hampered by the expense and difficulty of transport.

In 1868, Sir John Peter Grant with great foresight made the first attempt at another culture, one which could be carried on at higher elevations, namely of cinchona. The experiment was a complete success, for the government established the fact that cinchona could be grown in the island, and realized a sum of about £17,000 by the sale of bark. But for the very reason that the whole region was without roads, planters hesitated so long about embarking in the new industry, that the golden opportunity was lost, the price of cinchona bark fell, and

many persons lost money in the venture, whereas in Ceylon, with good roads and railways, fortunes had been made by all the pioneers.

Here in Jamaica, the loss to private individuals of large sums in cinchona planting, coinciding with the low prices for coffee and general depression in trade, led to the cry some ten years ago that the Hill garden instituted by Sir J. P. Grant had proved a failure, and should be abandoned. Fortunately this desponding wail has not been generally supported in the island, nor acceded to by the government. Six or seven years ago, Mr. Thistleton-Dyer, the director of Kew gardens, gave it as his opinion that it was quite possible that the Hill garden might again become the chief botanic garden of the island, and this prophecy, unlikely though it might have seemed to most, seems now in a fair way to become fulfilled, and to justify the faith of the few. The garden is situated about half way between Newcastle and Abbey Green, and the elevation of the government property ranges from about 3000 to 6300 feet, so that greatly varied experiments can be made in cultures requiring different altitudes.

The Hill garden, however, was not devoted solely to the cultivation of cinchona. Vegetables have been grown and instruction imparted so successfully, that all the settlers round for many miles grow such "English" vegetables as peas, cabbages, carrots, turnips, potatoes, artichokes, horse-radish, cucumbers and beets. Tea has been grown of a quality declared by London brokers to be excellent, and an order has just been received from a planter for 1000 plants. Timber trees of various kinds have been planted out and tended for years, and a knowledge gained of the capabilities of different trees for use in these hills where nearly all the valuable timber has already been cut. The nurseries at present contain some thousands of seedling trees. Fodder plants have been under experiment as well as many different kinds of economic plants, which will be taken up by planters in the near future, such, for instance, as jalap, which sells at 1s 6d per lb., orris root at 75 to 80s per cwt., China grass, a variety of ramie which can only be grown successfully in the hills, and

realizes twice the price of the tropical ramie, and fruit trees of temperate climates, and of high elevation both in the new and old worlds.

As this region is the best in the island for coffee, it is reasonable to suppose that it is the best for oranges, since the soil requirements of both are much the same. Although no tests have been made in comparing the oranges of Manchester with those grown here, many who know both, declare in favor of those grown in the Port Royal mountains where splendid fruit is produced at as high an elevation as 4100 feet.

The government has very lately established an orange experimental garden and nursery as part of the Hill garden establishment at an elevation of about 3900 feet. A large number of budded and grafted trees have been imported from Florida, and also from Rivers in England, who supplied growers in Florida and California in the early days of their groves. These are permanent stock trees, from which buds will afterwards be taken for budding on Seville and lemon stocks. Several thousand seedlings of the above stocks are being grown, also of the Jamaica sweet orange, grape fruit, tangerine and shaddock. Olives have been grown in the island for many years, but so far no fruit, or even a flower, has been produced. It is probable that this may be accounted for by their having been planted at too low an elevation. Eighty plants of the variety frantojo, which yields an excellent oil, have just been presented for trial by Lord Malcolm, of Knockalva, and these, together with others from Florida, have been put out at various elevations ranging from 3500 feet to 5500 feet.

Grape plants from Persia have been imported from California They grow on the table-lands of Persia, have a distinctive character of their own, and are very highly spoken of by travelers. They ripen early, and as they have a firm and tough skin they will probably prove serviceable for early shipping. The native grape of Jamaica, so abundant in these hills, though of no value as a fruit, may turn out to be of special worth for grafting the more tender European varieties.

These are a few of the cultures which may be taken up when roads are made. The prosperity of Jamaica will advance by leaps and bounds with the increased production rendered possible by means of communication, and a temperate climate all the year round will be available for invalids, within a few hours' drive of Kingston. But these benefits will also attract settlers from England when it becomes known that we have a Florida and a California in an island under British rule, with all the advantages of those climates and none of the disadvantages. Elevation 3000 to 6300 feet; annual mean temperature at 4900 feet is 62–67° F.; average rainfall, 105–114 inches.

CASTLETON GARDEN.

The drive from Kingston of nineteen miles, though a long one, is full of interest. The start is made in the fresh cool air of dawn; the road leads through the plain of Liguanea with a view of the hills in the distance, bright with the ever-changing hues of early daylight. Then the ascent becomes steeper, passing by settlers' groves of cocoa, coffee, and bananas, with a sprinkling of oranges, akees, sugar-cane, annatto, and yams. The road passes over the crest at an elevation of 1360 feet at Stony hill; thence down into the valley of the Wag water, with broad alluvial stretches covered with tobacco, cultivated by Cubans; along the winding river fringed with clumps of graceful bamboo plumes, and its banks hidden by masses of creepers; past the rocks by the roadside covered with ferns, mosses, the scarlet "dazzle," and the blue Jamaican "forget-me-not," until Castleton is reached, where art shows nature at its best by world-wide selection and harmonious combination.

At the principal gate stands one of the most superbly beautiful of all trees, the *Amherstia nobilis*, which, when in flower in the spring, is worth crossing the ocean to see. Further on we see *Norantea guianensis* climbing over a large tree, and brilliant with long spikes, not of flowers but of nectar-secreting bracts; *Mesua ferrea* attracting attention not so much by its large fragrant white flowers as by the red color of the young drooping

foliage; the mangosteen with its delicious fruit; the travelers' palm of Madagascar; *Araucaria excelsa* from Norfolk island. The palmetum contains specimens of 180 species of palms with great variety of graceful forms. The water lily tank is wonderfully beautiful with its surroundings of palms, bamboos, and grassy slopes, and the placid surface of bright water on which float the symmetrical leaves of red, white, and blue lilies, and the *Victoria regia* in the center, queen of the rest. From the brightness of the still lily pool we pass to the grateful shade of the ferneries with the quick stream dancing over the stones, and then on to examine the nutmeg tree, its yellow fruit splitting and displaying the "mace," a network of scarlet covering and half concealing the brown nut; the spicy clove and cinnamon trees; the climbing vanilla and black pepper; the coffee, cocoa, and kola trees; the peculiar flowers of Couroupita and Napoleona.

There is a small hotel in the grounds of the garden, open during the winter months, and as the importance of the garden has increased, a post and telegraph office and constabulary station have been lately erected. The railway station at Annotto bay is only nine or ten miles distant.

Elevation 580 feet; annual mean temperature 76–82° F.; average annual rainfall 113.15 inches.

BATH GARDEN.

The Bath garden, forty-four miles east of Kingston, is situated in one of the most tropical districts in the island. In other places, *e. g.*, in Hanover, it could easily be imagined that the road led through some English park, until we perhaps notice the sensitive plant (*Mimosa pudica*) trailing amongst the grass, or come upon a gigantic ceiba tree with buttressed trunk and its branches stretching far and wide loaded with a whole garden of exotic epiphytes. But in the Bath district the luxuriance of the vegetation arrests the attention on all sides. The street of the village has an avenue of the Otaheite apple (*Eugenia malaccensis*), which carpets the road with its purplish-red stamens. *Spathodea*

campanulata, a large tree with reddish-orange flowers, from tropical Africa, has become quite naturalized. The upas tree and the durian both grow in the garden, as well as the talipot or umbrella palm of Ceylon (*Corypha umbraculifera*), which has fan-shaped leaves twelve feet in diameter.

The sea is only six miles off, where there is a large sheltered bay of shallow water, protected by a bold headland and small bays; here search may be made for marine algæ.

About a mile and a half from the village, by a road along the side of the gorge, we come to the famous bath dedicated to St. Thomas the apostle. It is a hot spring of mineral water, efficacious in rheumatic and gouty complaints. This gorge is an unfailing delight for its picturesque beauty, and the botanist finds something new at every step. There is a bridle path across the mountains to Port Antonio, sixteen miles distant by the Cuna-cuna pass. This pass is an easy ride of six and one-half miles from Bath through virgin forest.

The forest commences close at the other side of the village. Most of it at one time or another has probably been cut for negro provision fields, but at a distance only of two or three miles undisturbed forest can easily be found, where the palm, *Calyptrogyne Swartzii*, flourishes, its stems clothed with that rare tropical American fern *Anetium citrifolium*. The John Crow, or Blake mountains, are unknown land, and it is said that the Maroons alone penetrate into their fastnesses in hunting wild pig. Inspector Thomas of the Jamaica constabulary crossed them a few years ago, and published an account of his expedition, but he is the only white man who is actually known to have ventured into them. These limestone mountains are of some considerable elevation (about 2000 feet), and are only ten miles from Bath, seven miles of which can be ridden. They ought to prove a happy hunting ground for the botanist. There are specimens of two species of tree fern, *Cyathea conquisita* and *C. pendula* in the British Museum, collected by Nathaniel Wilson who lived at Mansfield, two miles from Bath, but they have never been found since, and it is quite possible that he may have come

across them near the John Crow mountains where no botanist has ever been since his time. The soil at Bath is alluvial, deep and rich. The rainfall is heavy, being on the borders of the district which is classed by Maxwell Hall as having the heaviest fall, viz., over 100 inches in the year.

The garden is only a remnant of Nathaniel Wilson's garden, but is maintained by government as a small arboretum. It contains several trees of great interest and beauty, and is much more tropical in its aspects than any of the other gardens. Elevation 70 feet; mean annual temperature 79–85° F.

THE FLORA.

Jamaica is a paradise for the botanist, whether he specializes in algæ, fungi, mosses, ferns, or flowering plants. Of ferns there are about 450 species, and of flowering plants 2180 species; a number of both are endemic. Among the flowering plants are not only those found everywhere in the tropics, but types from North, Central, and South America, and the other West Indian islands.

Forty-four new species of mosses from a limited area in the Blue mountains have just been described in *Bulletin de l'Herbier Boissier*. A synopsis of the ferns is now appearing in the *Bulletin of Botanical Department*, Jamaica. Grisebach's *Flora of the British West Indies* is the only book that gives a connected account of the flowering plants. The flora of the whole of the West Indies is being thoroughly worked up now by Professor Urban, assistant director of the botanic garden of Berlin. The results of his labors appear in Engler's *Botanische Jahrbücher*. The monographs in continuation of De Candolle's *Prodromus* also contain later work than Grisebach's. In the *Jahrbuch* of the botanical gardens of Berlin Dr. Mez has published a monograph of the American Lauraceæ, including those of the West Indies.

ELEVATIONS.

The following table gives a general idea of the area in square miles embraced in the different zones of elevation, above sea level, in the several parishes:

Parishes	Area below 1000 feet	1000 feet to 2000 feet	2000 feet to 3000 feet	3000 feet to 4000 feet	4000 feet to 5000 feet	5000 feet and upwards	Total areas in square miles
Kingston	6½	⅔	..	..	..	..	7⅙
St. Andrew	59	54	27	17½	8	½	166
St. Thomas	135	59	35	20	14	11	274
Porteana	94	89	40	32½	17	12½	285
St. Mary	110	116	19	4	..	..	249
St. Ann	85	337	54	..	..	..	476
Trelawny	166	135	32	..	..	..	333
St. James	139	90	5	..	..	..	234
Hanover	161	6	..	..	..	..	167
Westmoreland	235	73	..	..	..	..	308
St. Elizabeth	335	120	7	..	..	..	462
Manchester	42	134	126	..	..	..	302
Clarendon	314	115	45	..	..	..	474
St. Catherine	336	124	10	..	..	..	470
Totals	2217½	1,452⅔	400	74	39	24	4,207⅙

Year	Rainfall divisions				The Island
	N. E.	N.	W. C.	S.	
	In.	In.	In.	In.	In.
1870	110.60	83.09	102.98	61.07	89.43
1871	69.45	41.88	54.56	34.46	50.09
1872	59.42	40.79	51.50	29.02	45.18
1873	84.08	52.64	67.79	47.71	63.06
1874	97.18	68.25	62.97	47.35	68.94
1875	71.89	47.15	56.16	34.47	52.42
1876	90.38	54.71	87.33	52.99	71.35
1877	100.72	56.53	64.06	52.27	68.40
1878	104.12	62.99	72.44	66.11	76.42
1879	122.55	65.44	87.54	79.85	88.84
Means	91.04	57.34	70.73	50.53	67.41
1880	76.37	47.01	64.91	33.47	55.44
1881	91.24	49.42	75.32	58.42	68.60
1882	65.48	43.76	78.59	43.67	57.87
1883	72.30	41.52	78.19	45.02	59.26
1884	69.00	41.87	73.10	43.63	56.90
1885	70.55	52.77	72.62	43.52	59.86
1886	126.61	60.98	88.21	86.64	90.61
1887	80.25	61.07	80.14	61.16	70.66
1888	98.00	54.42	70.43	65.58	72.11
1889	99.81	56.82	75.94	64.02	74.15
Means	84.96	50.96	75.74	54.51	66.54

RAINFALL.

THE JAMAICA RAINFALL FROM 1870 TO 1889.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1870.........	3.99	4.35	3.10	2.79	17.38	3.58	4.33	5.72	8.05	16.74	12.50	9.90	89.43
1871.........	2.40	1.60	2.29	3.46	6.43	1.98	3.79	3.46	5.70	8.88	5.88	4.22	50.09
1872.........	3.00	2.84	3.06	2.06	5.18	2.41	2.89	5.24	4.55	6.09	3.13	4.73	45.18
1873.........	8.15	1.94	5.47	1.15	5.06	2.58	2.56	7.51	10.73	8.57	3.53	5.81	63.06
1874.........	3.44	2.20	0.61	4.40	10.65	3.96	2.51	9.65	6.82	11.69	10.52	2.49	68.94
1875.........	2.57	0.67	2.59	3.05	8.54	3.74	3.87	5.13	7.60	5.58	2.34	6.74	52.42
1876.........	6.00	0.96	1.63	4.68	8.24	5.40	8.15	5.06	5.19	11.36	8.96	5.72	71.35
1877.........	5.94	1.18	5.38	2.91	15.03	6.50	4.68	1.76	5.01	4.50	7.63	7.88	68.40
1878.........	6.35	2.80	2.78	0.70	4.86	6.63	5.85	10.80	7.43	11.29	7.32	9.61	76.42
1879.........	2.81	5.30	6.49	7.28	9.14	10.64	4.47	12.32	7.38	15.96	5.29	1.76	88.84
Means.......	4.46	2.38	3.34	3.25	9.05	4.74	4.31	6.66	6.85	10.07	6.71	5.59	67.41
1880.........	4.36	0.96	1.10	2.77	11.60	3.09	3.86	9.58	3.97	4.00	2.21	7.94	55.44
1881.........	1.22	4.01	1.30	4.63	10.28	5.56	4.77	6.21	7.68	12.08	7.52	3.34	68.60
1882.........	2.92	1.93	3.54	3.32	8.22	2.33	3.76	4.80	8.78	8.96	5.36	3.95	57.87
1883.........	5.49	3.50	4.08	3.34	5.29	4.98	3.15	5.42	7.82	8.15	5.12	2.92	59.26
1884.........	4.72	3.44	2.51	1.85	6.72	6.89	2.52	5.06	6.23	9.52	5.00	2.44	56.90
1885.........	1.73	1.49	1.47	4.73	4.90	3.32	3.02	6.19	6.22	6.37	4.74	15.69	58.86
1886..... ..	5.23	4.65	2.68	6.39	5.30	23.36	6.22	13.54	5.90	7.98	3.70	5.66	90.61
1887.........	6.02	2.32	2.38	4.47	9.32	8.89	7.19	6.91	5.77	8.47	8.17	0.75	70.66
1888.........	1.36	1.89	1.70	3.61	21.24	6.77	2.65	5.47	8.10	4.38	4.59	10.35	72.11
1889.........	4.78	0.90	4.19	6.71	7.82	12.52	6.08	5.12	8.20	10.49	4.37	2.97	74.15
Means.......	3.78	2.51	2.49	4.18	9.07	7.77	4.32	6.83	6.87	8.04	5.08	5.60	66.54

KINGSTON, JAMAICA.

BRIEFER ARTICLES.

VARIATION IN LEAF ARRANGEMENT IN A MAPLE.

SOME weeks ago my attention was called by a colleague here to a young maple tree growing against the south wall of one of the college buildings. This young tree, perhaps ten years old, is limited in its direction of growth by its position, and it receives direct sunlight only when the sun is sufficiently high to shine over the flight of stone steps just east of it. Thus it has only a partial eastern exposure, no northern exposure, and is free only at the south and west. Naturally the tree is unsymmetrical and leans southward, away from the building. Evidently, too, the tree has undergone hardship other than that of unfavorable, or at least limited position, for it has no main stem, and its two or three largest branches do not balance well.

Of these larger branches one is remarkable in the arrangement of leaves and branchlets. The leaf arrangement of this tree is normally opposite, the pairs of leaves alternating regularly, and bearing a bud in each axil. The buds of former years have developed normally, in pairs and alternating. One branch, however, pointing southward and upward at an angle of about 45°, bears leaves and branchlets in threes, the whorls of three alternating regularly, so that the leaves and branches do not stand directly over one another. The branchlets, on the contrary, bear leaves in pairs, regularly alternating and therefore typical in arrangement.

On examining the lateral buds which are borne in the axils of the leaves developed in whorls of three, one sees a possible reason for such a diversity in the phyllotaxy of the branch and of its branchlets. Obviously each axillary bud develops in a space limited by two opposite organs, branch and leaf, capable of offering a certain amount of resistance to any structure developing between them. But on the other two sides no such resistance can be offered, for there is no older and stronger structure. It is true that the base of the petiole of the maple leaf is concave on the upper side, and that it clasps the branch more or less; but obviously far more resistance can be offered to the

growth of a bud and of any of its coverings from the moment of their origin as papillæ on the side of a growing-point, by the branch and the part of the petiole opposite it, than by the thinner, weaker, and really more distant opposite sides of the more or less clasping concave petiole. Examination shows that the outermost bud scales of all the lateral buds of this little tree, whether these buds are borne on the branches with paired leaves or on the one with leaves in whorls of three, are invariably opposite the spaces between branch and petiole, only the bud scales of the second and next inner pair being opposite the branch and petiole. Similar examination of the terminal bud of a branch with paired leaves shows that its outer pair of bud scales are alternate with the preceding pair of leaves, and its paired bud scales are regularly alternate, suggesting the regularity in arrangement of the parts within, and promising a continuance of the regularity in the branch which will develop therefrom next year.

On the other hand, the terminal bud of the one branch bearing its leaves in whorls of three has bud scales in whorls of three, the scales of the outer whorl alternating in position with the three leaves immediately behind this terminal bud, the bud scales of the succeeding whorls alternating regularly, and thus suggesting the same arrangement for the parts within, and prophesying a continuance of this arrangement of leaves on the nodes to be separated by growth of the internodes, and on the nodes to be formed, next season.

It seems to me, therefore, that in this little tree we have not only an interesting case of variation, but also an illustration of those influences — be they merely mechanical, as Schumann[1] would claim, or due rather to the arrangement of the deeper-lying conducting-tissues and hence connected with nutrition — which, if they do not altogether control, at least strongly influence the arrangement of the leaves and other structures formed at successive nodes. I am unable to discover any indications of what might have caused the different leaf-arrangement in the bud from which the present branch bearing leaves in threes has developed. It is of course easy to speculate as to possible causes, and perhaps if the branch were cut off, and examined microscopically at the base, evidences of the cause of the present difference might be found; but there are reasons which seem to me sufficient, for allowing this branch to grow on unmeddled with. We have then the variation, its cause being unknown. In the regular alternation of the leaves and the

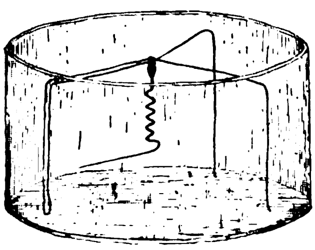
[1] Morphologische Studien, Heft I: Die Blattstellungen in gewundenen zeilen.

bud scales, whether in threes or twos, we have at least a suggestion that the "sport" was caused by the same influences which continue to affect if not to effect the alternation ; namely, on the one hand, the mechanical resistance which the growing papillæ, which develop into leaves or branches, would encounter were they to grow in certain easily recognized directions, and their freedom from this resistance if growing in other directions ; or, on the other hand, the disposal of the subjacent conducting-tissues, which would affect the nutrition of the vegetating point, and so might favor the formation and growth of leaf and branch papillæ (*Anlagen*) in positions alternate rather than opposite to older or already developed parts.—GEORGE J. PEIRCE, *Stanford University.*

HYGROMETER MADE WITH ERODIUM AWNS.

[THE following letter, together with some Erodium awns, was sent me a short time ago by Mr. Walter R. Shaw. I find upon trial that the awns are admirably fitted for the purpose indicated, and that the construction of an efficient hygrometer with them is a simple operation. Believing that others will be glad to make use of this method of demonstration, I have asked the privilege of publishing the letter and the sketch that accompanied it.—J. C. ARTHUR.]

I have found the awns of *Erodium cicutarium* an excellent substitute for those of Stipa in the Darwin transpiration hygrometer. Erodium is very common in some parts of California. A piece of iron wire bent in the form of a tripod serves to support the awns in the crystallizing dishes better than the mechanical cross bars that were supplied some time ago. The seed on the awn is easily attached to the tripod by a small bit of wax or paraffin with a hot needle. The tripod has the advantage that it may be instantly revolved to any position inside the dish without throwing the awn out of the axis of the vessel. The Erodium awn carries its own pointer. On the whole, less dexterity is required in its manipulation, and it has been shown to be more sensitive to humidity than the longer awns of Stipa.—WALTER R. SHAW, *Stanford University.*



Hygrometer made with crystallizing dish, in which an Erodium awn is supported on a tripod formed by bending a single piece of iron wire.

A METHOD OF PRESERVING ALGÆ.

ALGÆ for demonstration purposes may be preserved without trace of shrinkage and mounted for permanent use in the following manner: Kill and fix in Flemming's weaker formula (10^{cc} 1 per cent. osmic acid; 10^{cc} 1 per cent. acetic acid; 25^{cc} 1 per cent. chromic acid; 55^{cc} distilled water). This may be used from one-half hour to twenty-four hours or more without injury to delicate tissues. Next drop 10 per cent. glycerine directly into the fixative. Be careful to allow each drop to diffuse before adding more. This guards against shrinkage which is caused by diffusion currents if glycerine is added too rapidly. Continue adding drop by drop until enough glycerine has been put in to cover the specimens when evaporated. The fixative and water should now be allowed to evaporate in a watch glass where a large surface is exposed. The specimens may now be handled with a needle or knife and arranged on the slide under a dissecting microscope. A drop of pure glycerine or of glycerine jelly makes a very satisfactory mount. Glycerine jelly has to be used very carefully, but it is the more satisfactory when it can be used with success. Filamentous forms should be cut while fresh into pieces of convenient length for handling.

This glycerine method is extremely convenient for preserving fruiting forms, for demonstration of swarm spore and zygospore formation. The more delicate stages may be fixed and mounted on the slide so that they need only be handled once. The method was devised and thoroughly tested in the laboratory of Lake Forest University last year. Since leaving Lake Forest I have used it successfully in preserving red algæ at Wood's Holl. Some of them, as Dasya, retain their color almost perfectly under this treatment. Although color in green algæ is more or less sacrificed, the chromatophores retain their shape perfectly, while the cells as a whole become even clearer than fresh material.—CHAS. THOM, *Missouri State University.*

NOTES ON THE WOODY PLANTS OF THE SOUTH ATLANTIC STATES.

I HAVE collected at several places in the mountains of the southern states a Fothergilla which is evidently distinct from the coastal plant. Descriptions of both are given, taken from a large number of specimens. The Alabama plant I have not seen.

FOTHERGILLA CAROLINA (L.) Britt. A low shrub with erect or spreading branches, reaching a height of 0.6^m or rarely 1^m: leaves 2 to 4^{cm} long, 1 to 2^{cm} wide, oblong or obovate, rounded or cuneate at base, obtuse and usually emarginate at apex, denticulate to coarsely crenate above, thickish, dull green and smooth on the upper surface, below paler and somewhat glaucous, smoothish or soft pubescent with brown or fulvous hairs, with 3 or 4 pairs of prominent straight veins; petiole pubescent, 2 to 4^{mm} long; stipules minute, 2 to 3^{mm} long, deciduous: terminal bud and young twig soft pubescent, bud 3 to 4^{mm} long: style 6 to 8^{mm} long: capsule clothed with fulvous pubesence, the styles erect and parallel: seed 4 to 5^{mm} long.

I have been unable to secure specimens of this plant from farther south than southern South Carolina, but expect that the plant which has been collected in central Alabama is referable to this species.

Fothergilla monticola, sp. nov. A bushy shrub, commonly dividing near the base into erect virgate branches, with dark brown or reddish minutely roughened bark, reaching an average height of about 1.2^m, or exceptionally even 2.5^m: leaves 8 to 12^{cm} long, 5 to 8^{cm} wide, oval, broadly obovate or nearly orbicular, cordate, subcordate or truncate and unequal at base, rounded or obtusely pointed at apex, irregularly crenulate or undulate even to the base, membranaceous, bright green on both sides, smooth or nearly so even when young, the 4 to 6 pairs of prominent parallel veins terminating in short mucros; petiole slender, 1 to 1.5^{cm} long; stipules ovate-lanceolate, acuminate, 5 to 7^{mm} long, somewhat persistent: terminal bud naked, flattened, sericeous, about 5^{mm} long: twigs mostly smoothish, red-brown: flowers unknown, but style 1^{cm} long, evidently longer than in *F. Carolina:* spikes 3 to 5^{cm} long: capsules larger than the preceding, clothed with grayish pubescence; styles divergent: seed grooved at the top, 6^{mm} long.

Rocky woods, mountains of Virginia to South Carolina, between 400 and 1200^m elevation.

The only published name which could possibly apply to this species is *Fothergilla major* Lodd.[1] This description is from cultivated plants which seem to be only vigorous specimens of *F. Carolina*, and are described as having spikes over three inches in length, late in flowering, and leaves broad and much toothed. The limited distribution of *F. monticola*, and the fact that none of the early American botanists recognized more than one species, though Elliott remarks that the species (the coast plant) is variable in the color of

[1] Botanical Cabinet, 1720.

its stamens, and possibly contains more than one species, would seem to show that the mountain species was unknown to them. Dr. M. A. Curtis was aware of the occurrence of a Fothergilla in the western part of North Carolina of greater size and with larger leaves than the plant of the eastern part of the state.

ZENOBIA SPECIOSA PULVERENTULA (Michx.). (*Andromeda speciosa* var. *pulverentula* Michx. Fl. 1: 256). Leaves thinner, more oval, crenate, persistently densely white pulverulent beneath.—A well-marked form, sometimes growing with the type, but usually separate, occurring in North and South Carolina.

SMILAX AURICULATA Walter. There seems to be no reason why this name should not replace the later *S. Beyrichii* of Kunth. The only objection urged against applying Walter's description to this species is that he gives the color of the berries as being purple, while they are black when ripe. All through the winter, however, until they ripen in the spring, they can be found all shades of purple.

SMILAX LAURIFOLIA BUPLEURIFOLIA Delile occurs from eastern South Carolina, where it was originally collected by Curtis, to southern Virginia. Its very long and narrow leaves make it quite distinct from *S. laurifolia*, though in other respects I can detect no difference.

SMILAX LANCEOLATA L. is usually considered to be an annual-fruiting species, but the few specimens which I have found in fruit evidently ripen their seed the spring after the summer when they flowered. It does not flower until July, and the berries, which by winter are yet small, remain green or somewhat reddish until the following spring.

Quercus pagodæfolia (Ell.), nom. nov.

Q. falcata var. *pagodæfolia* Ell. Bot. 2: 605.
Q. digitata pagodæfolia (Ell,) Ashe, Handbook of N. Car. 47. 1896.

Leaves oval or oblong, 8 to 12^{cm} long, 4 to 8^{cm} wide, with 3 to 6 pairs of prominent straight veins, and as many usually entire narrowly triangular lobes separated by deep rounded sinuses, the lobes divaricate or projecting somewhat towards the apex, thick, above dark green, below persistently white tomentose; petiole 3 to 4^{cm} long, slender, tomentose: twig 2 to 3^{mm} thick, persistently white tomentose: buds 2 to 4^{mm} long, acutish, bright brown, the scales nearly smooth: cup 1 to 2^{cm} wide, shallow, scales large for the group, appressed, smooth or downy; nut barely 1^{cm} thick, scarcely larger than that of *Q. digitata*, globose, one-half enclosed in the cup: seed yellow and bitter.

A large tree reaching a height of 25 to 32^m and a diameter of 0.8 to 1.1^m, with an oval or oblong crown and spreading branches, the rough checkered bark of the trunk dark gray or blackish and somewhat striped, that of the limbs smoothish and dark gray. River swamps eastern Virginia and North Carolina to southwestern Georgia. Although not a common tree, several specimens usually occur together where it is found. It is usually associated with *Quercus Michauxi*, *Q. nigra*, and *Liquidambar*. The original locality of Elliott is on the Roanoke river near Weldon, N. C.; he also found it in South Carolina. I have found it on the bottom lands of the Roanoke, Neuse, and Cape Fear rivers in North Carolina, where it extends some distance westward in the Piedmont plateau region; and in southwestern Georgia where it occurs along the Flint river.

This tree is evidently not a hybrid, as it shows no intermediate characters between *Q. digitata* and any other species. The shape of the nut is globular as is that of *Q. digitata*, the cup somewhat deeper; the pubescence is white, while that of *Q. digitata* is more often tawny and is more persistent than that of *Q. pagodæfolia.*

QUERCUS TEXANA, which is a rare tree in the Atlantic states, seems to be entirely absent from the coastal region. In North Carolina it is confined to the Piedmont plateau, but does not occur above an altitude of 200^m. In northern Georgia it is found as high as 350^m. In certain parts of the Flint river valley of southwestern Georgia it is more common, often being associated with the red oak, from which, under the common name of spotted oak, it is often not distinguished by the inhabitants.

ILEX LÆVIGATUS (Pursh) Gr. occurs abundantly in certain parts of eastern North Carolina and South Carolina, though it does not seem to have been recorded at all from this region. There can be but little doubt that this is the *Ilex lanceolatus* of Chapman's *Flora* (*Prinos lanceolatus* Hill, Veg. Syst. **16**: 57. *pl. 61*) as the description and distribution agree well with that given for the *Prinos lanceolatus*. In this case the earlier *lanceolatus* will replace *lævigatus*. I have specimens of the plant from nine localities in North and South Carolina, all of them between 40 and 100 miles of the coast.

ILEX AMELANCHIER M. A. Curtis. Several stations have been found for this uncommon plant in North Carolina and one in southern Virginia. It has not hitherto been reported from further north than the original station at Society Hill, S. C. While not entirely confined to the Piedmont region of the Carolinas it seldom enters the coastal plain, and does not occur above an altitude of 350^m.

Ilex Beadlei, nom. nov. *Ilex mollis* of southern authors, and in part that of Gray's Manual. *Prinos dubius* Don[2] is usually given as a synonym for this species, but the original description will scarcely apply to *I. Beadlei*, and the distribution assigned to *Prinos dubius*, from North Carolina to New Jersey, barely even extends as far south as the most northern point where *I. Beadlei* is known to occur. The distribution of *I. Beadlei* is from King's mountain, North Carolina, westward through the southwestern part of North Carolina, to northern Georgia, eastern Tennessee, and probably to northern Alabama. This species reaches its best development and is most abundant in and around Ocoee county, Georgia. The name proposed for the species is in honor of Mr. C. D. Beadle, Curator of the Biltmore Herbarium.

Ilex ambigua (Michx.) Chapm., which is the smallest and most delicate of the southern species of the genus, probably does not occur north of the Neuse river in North Carolina, its distribution terminating with that of the sand hills on which it grows.

Rhus aromatica mollis (Gray) (*R. Canadensis* var. *mollis* Gr.) occurs in North and South Carolina only in the Piedmont region, not being found above 250^{m} altitude. Besides being densely pubescent beneath, the leaflets, in all the specimens which I have seen, are considerably broader than in *R. aromatica*.

Dendrium buxifolium prostratum (Loud.) (*Leiophyllum prostratum* Loud.), collected from the summit of Table Rock at 1000^{m} altitude, has nearly the same characters as that from the summit of Roan mountain, at nearly twice that altitude, while *B. buxifolium*, collected at an altitude only a few meters below that of Table Rock, has the oblong and more scattered leaves of the coast plant, and can scarcely be distinguished from it in the dried material. Though slight, the characters between the two plants seem to be well marked and persistent.—W. Willard Ashe, *Forester, Geol. Survey, Raleigh, N. C.*

[2] Mill **2**: 20.

OPEN LETTERS.

ON THE VALUE OF SECTION NAMES.

I HAD imagined that when a section was given generic rank, there would not be any difference of opinion, at the present day, as to the generic value of the section name, provided always that it agreed in form with generic names, and was the earliest name (not preoccupied) for the group. In the just published *Contrib. U. S. Nat. Herb.* **5**: no. 3, Dr. Rose takes a different view, and uses names for two genera (*Vaseyanthus* and *Brandegea*) which are of later date than section names which he places in their synonymy. It is evident that he feels justified in doing this because the generic names were proposed as generic names at a time when the section names were not known to represent the same groups. As the matter is of some importance, it may be well to test it by these cases, so I give the two alternatives. Dr. Rose writes thus:

(1) GENUS, Vaseyanthus Cogn. 1891; SYN. Echinocystis § Pseudoechinopepon Cogn. 1890; TYPE, *Vaseyanthus Rosei* Cogn. 1891.

(2) GENUS, Brandegea Cogn. 1890; SYN. Sicyos § Heterosicyos S Watson. 1888.

It seems to me it should be:

(1) GENUS, Pseudoechinopepon Cogn. 1890; SYN. Vaseyanthus Cogn, 1891; TYPE, *Pseudoechinopepon Brandegei* (Cogn. 1890).

(2) GENUS, Heterosicyos S. Wats. 1888; SYN. Brandegea Cogn. 1890; TYPE, *Heterosicyos minimus* (S. Wats. 1888).

—T. D. A. COCKERELL, *Mesilla, N. M.*

CURRENT LITERATURE.

BOOK REVIEWS.

Index to Saccardo's Sylloge.

A COMPLETE index to Saccardo's great work on fungi has been compiled by Dr. Sydow.[1] The first half of the volume was issued in advance, and was noticed in this journal for last May. The index is divided into five parts: the first part includes species growing on living or dead parts of plants (858 pages); second those on living or dead parts of animals and man (14 pages); third those found on artificial substrata, such as paper, bread, etc. (30 pages); fourth those on earth, stones, etc. (137 pages); and fifth those that are fossil (13 pages). The bacteria are excluded from the index. The alphabetical arrangement is by genera, with species under each genus. The kind of substratum (hosts being mentioned by name), and the geographical distribution are also given in the same line.

The index is almost invaluable to one who uses the work much, and is a fitting complement to the eleven volumes of specific descriptions. The typography is admirably suited to ready reference.—J. C. A.

The bacteria.[2]

THE author of this valuable addition to bacteriological literature is well known to English readers through the translation of his *Introduction to Practical Bacteriology*, as well as through his original contributions to our knowledge of bacterial structure and function. The present work is an exceedingly useful and usable compilation. It deals with such questions as the relationship of bacteria to other groups of organisms, and the orderly arrangement possible within the group itself; with the morphology and chemistry of the cell membrane, the structure, chemistry and reaction to stain of the cell contents, the problematic cell nucleus and *Centralkörper*; and

[1] SACCARDO, P. A.—Sylloge fungorum omnium hucusque cognitorum. Vol. XII; Index universalis et locupletissimus generum, specierum, subspecierum, varietatum hospitumque in toto opere (vol. I–XI) expositorum. Auctore P. Sydow. Roy. 8vo. pp. 1053. Berolini: Fratres Borntraeger. 1897.

[2] MIGULA, DR. W.—System der Bakterien. Handbuch der Morphologie, Entwickelungsgeschichte und Systematik der Bakterien. Erster Band. Allgemeiner Teil. Mit 6 Tafeln. Jena: Gustav Fischer. 1897.

with the question of bacterial motility including all the vexed and difficult problems connected with the origin, distribution and significance of the flagella. There are important chapters upon growth and division and the formation of cellular unions or colonies, and upon spores and gonidia, and pleomorphism and variability. The "general part" comprised in the volume before us, and presumably to be supplemented some day by a "special part," concludes with an interesting section upon the biological characteristics of bacteria, in which are discussed such phenomena as pigment production, anaerobiosis, parasitism, phosphorescence, the action of light and temperature, and the special metabolic activities displayed by the sulphur, the iron, and the nitrogen bacteria. The merit of the whole treatise is that it brings together the information obtained through the researches of the past few years and presents it in a careful and lucid way.

The author's system of classification is already well known from its appearance something over a year ago in *Die Natürlichen Pflanzenfamilien* (Lfg. 129).[3] It is simple and consistent, and at least does not include hypothetical genera to be hereafter discovered for the delectation of the scientific imagination.

It may be questioned whether our author has made the best use of his space in threshing over the old facts of the historical development of classification and nomenclature in the same thoroughgoing manner in which it has already been done. It must be confessed one is a little weary of seeing in monograph and text-book the same old "systems" trotted out for inspection again and again. The system of de Toni and Trevisan, for example, has certainly not proved such a help to bacteriology that we are justified in keeping it constantly before our eyes. Such systems are the flotsam and jetsam of progress, and if they are fain to sink of their own weight should be allowed to do so. The fetish of completeness, however, is conspicuous throughout the book, and much valuable space is sacrificed to it. The irrelevant and the trivial do not deserve a place by the side of the significant and essential, and the writing of such a book as this should presuppose the selection and sifting of material.

The author's treatment of the cell nucleus question is, on the whole, discriminating and fair. He refuses to accept Bütschli's statements as to the existence of a *Centralkörper* in bacteria, and denies that bacteria possess a true cell nucleus "like the cell nucleus of higher plants," but is inclined to look upon the metachromatic granules observed in the cell contents as a sort of primitive nuclear substance.

Migula takes germination as the criterion of a spore, a process which in a true spore differs essentially from the proliferation of a vegetative cell, and on this ground gives no credence to the existence of arthrospores. He does

[3] See BOT. GAZ. **21**: 243. Ap. 1896, and American Naturalist, June 1896.

not lay so much stress as many recent writers have done upon the claims for extensive pleomorphism and variability among bacteria, and seems not to be acquainted with some of the available data in this field.

The index of the book is somewhat inadequate for a compilation of this character, and might be enlarged to advantage. The most serious typographical error that we have noticed is the mistake in numbering and placing Plates IV and V, so that each plate is faced by the description of the other. But when all shortcomings are taken into consideration, it still remains true that Dr. Migula's work is a distinct aid to all workers in bacteriology, and should give an impetus to the study of the purely scientific aspects of the subject.—E. O. J.

MINOR NOTICES.

THE PROCEEDINGS of the tenth annual convention of the Association of Agricultural Colleges and Experiment Stations has recently been issued in Bulletin no. 41 of the Office of Experiment Stations. They contain only one botanical paper, a vigorous presentation of the place of vegetable physiology in the curriculum of the agricultural colleges, by Professor Geo. E. Stone, of Amherst, Mass. This article, while addressed to agricultural colleges, is equally applicable to the conditions existing in most of the higher educational institutions in the United States, and deserves a wider reading than its form of publication is likely to bring. The author justly states that "there has been no branch of botany so neglected in our country as the physiology of plants." A very general awakening, however, has been recently experienced. As a pedagogical subject, nevertheless, it is still in a very unsettled condition, and it has been called upon to meet the damaging influence of specialists in other lines of activity, who permit inertia and mistaken notions to influence their attitude toward the new aspirant for position. The following sentences, quoted from the article, are so well said, and so much in need of being said, that they are reproduced here, and it is to be regretted that room is not available for more.

"The necessity of defining a branch like physiology is in itself a reflection on our botanical development, especially when there are so many excellent text-books treating physiology in a distinctly characteristic manner. Nevertheless such misconceptions exist, and I feel justified in calling attention to them. There has never been any question as to what physiology implied among the animal physiologists; neither has there been any among European vegetable physiologists. But right here in our American agricultural institutions we have had professors of botany who did not, and do not today, seem to know exactly what ground this subject covers. One institution that I have in mind has advertised for years a thorough and complete equipment for work in vegetable physiology, and yet this very same institu-

tion has scarcely had a single piece of purely physiological apparatus in its outfit during the whole time. The institution I refer to by no means stands alone in the matter. There are others holding the same conception of physiology. The fact in regard to the matter is that there are still some botanists who insist in calling the study of the structure of a stem or leaf, or the mounting of a slide, etc., physiology.

"Physiology as treated by such eminent physiologists as Foster, Bowditch, Ludwig, DuBois Reymond and others, implies function, and I cannot understand how a botanist can even have looked into the text-books of Vines, Sachs, Pfeffer, Frank, and others, without obtaining a similar conception. Inasmuch as physiological botany concerns itself with function, it is essential that any extensive course in this branch must be preceded by a fairly good course in anatomy and histology. I believe, however, that in every elementary branch of botany the function of the plant should be taken into consideration.

"For a practical course in physiology considerable apparatus is needed. This is generally expensive, and when imported not always satisfactory from the American idea of machinery. Much of the apparatus can be constructed in the laboratory, providing a good set of tools is at hand. Much time is saved by having the apparatus all ready to put together at short notice, and for this purpose it is necessary to have a good stock of glassware on hand, which should be fitted up for the various experiments."

The whole article is as practical and incisive as the few sentences quoted indicate, and merits the attention of botanical teachers.—J. C. A.

WORK ON the North American mosses proceeds steadily from the herbarium of Columbia University. The last paper is "A Revision of the North American Isotheciaceæ and Brachythecia," by A. J. Grout.[4] Of the quality of such work only one who goes over it critically can judge ; but one has every reason to accept this as a real contribution to the knowledge of these mosses, and the more since the author had the benefit of the advice and the suggestions of Mrs. E. G. Britton.

Mr. Grout adopts *Entodon* for our species of *Cylindrothecium* and *Platygyrium*, *Pylaisiella* for *Pylaisia*, *Holmgrenia* for *Orthothecium;* removes *Homalothecium* from the Isotheciaceæ ; and drops *Isothecium* from the list of North American genera. Various changes are made in the list of species, both as to nomenclature and their presence in this country. Over most of these we breathe a sigh of relief, particularly over those affecting the names recently published by Kindberg and C. Müller. Through these the author cuts a wide swath. Four, only, stand ; the list of synonyms contains no less than twenty-seven names by these authors, seventeen by Kindberg and ten

[4] Reprinted as a doctor's thesis from Mem. Torr. Bot. Club **6**: 131–210. 1897.

by C. Müller and Kindberg, while three are relegated to the doubtful list, and two to the rank of varieties. *Brachythecium asperrimum* holds the record with *four* Kindbergian names as synonyms! Let the good work go on.—C R. B.

AT THE TIME of the death of Dr. Schröter, December, 1894, the *Pilze* of the *Kryptogamen-Flora von Schliesen* was within three parts of completeness. Part of the manuscript for the remainder was prepared, but about one signature had not been begun. The publishers have now issued one of the remaining parts[5] which carries the work through the *fungi perfecti*, and through eighty-five species of the *fungi imperfecti*, which is all the material the author left in readiness for the press.

The publishers express regret that they have been unable to secure a suitable person to complete the work upon the original lines. They therefore purpose to issue shortly a final part, to contain such species as Schröter had indicated, as shown by his fragmentary notes and the herbarium deposited in the Pflanzenphysiologisches Institut of the University of Breslau. It will also contain a supplement giving Schröter's changes and additions to the preceding parts, and will close with an index to the second volume.—J. C. A.

NOTES FOR STUDENTS.

FRIEDRICH OLTMANNS[6] has described the results of a recent study of the swarm spores of certain Phæophyceæ. He claims to have disproved the statements of Berthold,[7] as quoted in the standard texts, that in *Ectocarpus siliculosus* a large zoospore comes to rest, becomes attached to one to four small zoospores, and then fuses with them; also that zoospores from plurilocular sporangia fuse in pairs. The form most fully studied was *E. criniger*, in which unilocular sporangia, if present, were not discovered. The claim is that one is dealing here, not with a primitive condition of sexuality, but rather with infusorians which are eating the algal zoospores. The number of nuclei in the so-called zygote is invariably one greater than the number of chromatophores, and the extra nucleus differs from the others in appearance and staining reactions. The process of digestion of the spores can be followed, and the wastes are ejected as minute balls. These facts point to the infusorial nature of the larger organism. This conclusion does not deny all

[5] SCHRÖTER, J.—Kryptogamen-Flora von Schliesen, Dritter Band: Pilze. Zweite Hälfte, vierte Lieferung. 8vo. pp. 385–500. Breslau: J. U. Kern's Verlag. 1897. *M* 3.20.

[6] Ueber Scheincopulationen bei Ectocarpeen und anderen Algen. Flora **83**: 398–414. 1897.

[7] Die geschlechtliche Fortpflanzung der eigentlichen Phaeosporeen. Mitth. d. zool. Stat. Neapel **2**: 401. 1897.

sexual fusions among the spores of Algæ, but may explain many "abnormal" processes, such as the fusion of three or four zoospores in Acetabularia, etc. Many appearances in Dasycladus are due to abortions, the protoplasm having emerged from the mother cell before the zoospores are perfectly formed.

The author believes that Berthold saw nothing but the activity of infusorians, and confirms his views by drawings from some of Berthold's preparations. The fusion of nuclei in the zygote is nowhere seen. That Berthold found zygotes in only a part of his cultures, that he had so many female and so few male zoospores, and that his zygotes never germinated, all go to prove that the bodies were really infusorians. Oltmanns obtains his best results in cultures from three to four days old, those younger not giving the infusorians time to come into sufficient prominence. One can but regret that so important a paper should be accompanied by drawings so small as to make it difficult to distinguish chromatophore from nucleus, to say nothing of telling a zoospore nucleus from that of an infusorian.

Berthold's reply[8] immediately follows. Since Thuret, no one has denied that spores from plurilocular sporangia could germinate without fusion. Oltmanns did not see the sexually formed spores at all, and what he describes as Chytrideæ were described by Berthold in 1881 as products of the disorganization of male zoospores. The genuine zygotes are formed very soon after the spores are formed, and if formed at all are exceedingly numerous. Fusion of more than two zoospores is very rare. The existence of the extra (infusorian) nucleus is to be doubted. A series of memoranda, made while studying the living material, shows how some cultures could be recognized as composed of male, others of female zoospores, and still others of neutral spores capable of direct germination. From one lot of zygotes plants with plurilocular sporangia were finally obtained. Spores of one culture were nearly all alike; and cultures of male and female zoospores when mixed gave zygotes in the greatest number.

We agree with the two authors that little more is to be learned from mere discussion. Such directly conflicting statements can only be reconciled by further investigation.—W. D. M.

DR. C. O. TOWNSEND[9] has further investigated the relation of the nucleus to cell wall formations in a large series of plant cells. He finds that in every case the presence of a nucleus is necessary to enable a mass of protoplasm to enclose itself with a wall. This influence of the nucleus, however, can be transmitted to considerable distances between parts of the same cell separated

[8] Bemerkungen zu der vorstehenden Abhandlung von Fr. Oltmanns. Flora 83:415–425. 1897.

[9] Der Einfluss des Zellkerns auf die Bildung der Zellhaut. Inaug. Diss. Jahrb. f. wiss. Bot. 30:—. 1897. [Heft. 4.]

by plasmolysis, and from one cell to another, provided only that protoplasmic continuity through living fibers is maintained. The author believes that Palla's failure to observe such fine connecting fibers between plasmolyzed masses in pollen tubes led to his erroneous conclusion that the nucleus is not necessary to cell wall formation. Very interesting is the fact that mere contact between two plasma masses is not sufficient for the transmission of the formative influence of the nucleus from one to the other. Just what this rôle of the nucleus is in cell wall formation the author does not attempt to state.—R. A. H.

DR. C. ISHIKAWA of the Imperial University, Tokyo, Japan, has published a third paper[10] in his series of "Studies of reproductive elements." It treats of the pollen grains of *Allium fistulosum*, with special reference to the process of chromosome reduction. In this process he finds some important deviations from what has hitherto been regarded as typical of flowering plants. Although he did not succeed in observing the original delimitation of the sporogenous region from the ordinary tissue of the anthers, he obtained very young sporogenous cells in stamens which were just making their appearance as protuberances on the flower disk. In these early sporogeneous cells the nuclei were already distinguishable by poverty of chromatin; and in division showed the reduced number (eight) of chromosomes, the division being described as heterotypic. The chromosomes split longitudinally, and the segments during metakinesis remain attached by their ends so as to form rings. In the pollen mother cell the spirem is apparently one continuous ribbon, which, after a synapsis stage, becomes divided into segments having the chromatin granules arranged in double rows. The segments shorten and become sharply bent at the middle. Longitudinal fission is now complete, and the bent segments attaching themselves together in pairs at the point of bending give rise to eight X-shaped figures which resemble the tetrads of some animals. Metakinesis proceeds according to the heterotypic method. Arriving at the poles of the spindle, the eight V-shaped daughter chromosomes break transversely at the angle, and form sixteen rod-shaped granddaughter chromosomes. No complete resting condition ensues, but division of the pollen daughter cell into the pollen grains follows at once, according to the heterotypic method. The next stage, the formation of the vegetative and generative nuclei, presents no unusual phenomena. It may be added that in the first division of the pollen mother cell bodies resembling centrosomes were frequently observed.

Doubtless the most interesting observation in this account of spermatogenesis is the early reduction of the number of chromosomes. In all other flowering plants in which chromosome reduction has been investigated it is

[10] Die Entwicklung der Pollen-Körner von *Allium fistulosum* L., ein Beitrag zur Chromosomen Reduktion im Pflanzenreiche. Jour. Coll. Sci. (Tokyo) **10**: —.

said to take place in the pollen mother cell. So it has been described for *Lilium Martagon* by Strasburger, Guignard, Farmer, and Miss Sargant; also for *Larix Europæa* and other plants. In all these cases, too, the chromosomes are distributed by means of two longitudinal fissions; while in *Allium fistulosum* their distribution in the second division of the pollen mother cell is effected by transverse fission. It will be noted that in so far as the reduction in *Allium fistulosum* deviates from the ordinary plant type it approaches what has been reported in certain animals, especially in some copepods and Gryllotalpa, where the second division of the spermatocytes is attended by transverse splitting of the chromosomes, and the reduced number of chromosomes appears early, even as early in *Cyclops brevicornis*, according to Haecker, as the primordial cells of the blastula stage.

Transverse fission of chromosomes in plants has been reported by Calkins in Pteris and Adiantum, by Mottier in Lilium, and by Schaffner in *Lilium Philadelphicum*.—W. R. S.

NEWS.

THE SOCIETY for the promotion of Agricultural Science, at its recent meeting in Detroit, elected Professor B. D. Halsted, of New Brunswick, N. J., president for the ensuing year. The next meeting will be held in Boston in August 1898. The society includes a considerable proportion of active botanists among its members, and many papers of botanical interest are presented before it.

TO DETERMINE more exactly the distribution of the several trees popularly known as pignuts (including *Hicoria odorata* or *H. microcarpa*), Mr. W. W. Ashe, forester of the North Carolina Geological Survey, would be glad to get specimens of these trees, especially from Michigan, central New York, New Jersey, Pennsylvania and Delaware, and from all the southwestern states. The essential parts of a hickory specimen are vigorous twigs with well developed buds, and fruit and leaves. If desired he will return any material sent, and will determine any for persons wishing it. He may be addressed at Raleigh, N. C.

THE SUBTROPICAL LABORATORY at Eustis, Florida, under the direction of the Division of Vegetable Physiology and Pathology of the Department of Agriculture, has been abandoned as a station, and Messrs. Swingle and Webber should hereafter be addressed at Washington. The tropical work, however, will not be discontinued, but will be conducted hereafter from Washington as headquarters. A small garden tract and laboratory have been secured at Miami, Florida, where experiments can be conducted, and where work can be done with laboratory facilities whenever desired. It is expected to make a feature of introducing and testing varieties of tropical plants which can be grown successfully in the tropical and subtropical portions of the United States. Extensive experiments have been made in crossing and hybridizing the orange and other citrous fruits, pineapples, guavas, etc., and the resulting hybrids will be cultivated in this garden. It will also serve as a tropical station for amelioration experiments in the modification of some of our native fruits.

IN THE AMERICAN NATURALIST for October there appears a brief biographical sketch, with portrait, of the late Dr. James Ellis Humphrey. The sudden death of this most promising young American botanist came as a great shock to the whole botanical fraternity. From the sketch referred to the following details of his life and work are selected:

He was born in Weymouth, Mass., August 5, 1861, and received his early education in the Weymouth schools. In 1886 he graduated from the Lawrence Scientific School of Harvard University, with the degree of S.B., and was at once appointed an assistant under Professor Goodale. In 1887 he became instructor in botany in Indiana University, and in 1888 was appointed botanist in the Agricultural Experiment Station at Amherst, Mass., where he remained until 1892. At Amherst he continued his studies under the direction of Harvard, and in 1892 received from the university the degree of Sc.B. From that time until 1894 he studied under Professor Strasburger at Bonn, and returning to America was made a fellow in the Johns Hopkins University. In the next year he was appointed lecturer in botany in the same institution, and in the present year was advanced to an associate professorship. In June he visited Jamaica with a party of students, where he died August 17.

Dr. Humphrey's first published paper was on the development of the frond of the alga *Agarum Turneri*. At Amherst he naturally paid large attention to the fungi, and the reports of the Experiment Station contained many of his contributions upon plant diseases. In Strasburger's laboratory he directed his attention to cytological studies, and most of his later publications have been in this field. It was in the direction of cytological work that his botanical friends expected large things of him. For several years he has been the American correspondent of the *Botanische Centralblatt*, and also translated and edited Zimmermann's *Botanical Microtechnique*. At the time of his death he was one of the associate editors of the reorganized *American Naturalist*.

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UNDESCRIBED PLANTS FROM GUATEMALA AND OTHER CENTRAL AMERICAN REPUBLICS. XIX.

JOHN DONNELL SMITH.

Anona Pittieri Donn. Sm. (§ ATTAE, CHERIMOLIAE Mart. Fl. Bras. 13^1: 14)—Folia glaberrima crasso-chartacea opaca oblonga 4-plo longiora quam latiora, apice obtuso abrupte acuminata, basi obtusa, nervis lateralibus tantum subtus conspicuis paucis a margine remote anastomosantibus. Pedunculi laterales singuli aut fasciculati graciles. Petala inter maxima lineari-oblonga.

Leaves 16–18×4–5^{cm}, nerves about 12 to the side, petioles 6–8^{mm} long. Peduncles 1–5, equaling petals, flowers puberulous. Calyx 3^{mm} high, segments deltoid. Petals 3, triquetrous, deeply concave at base, 3.3×0.7^{cm}. Torus hemispherical, in anthesis 3^{mm} broad. Stamens 1^{mm} long, anthers twice longer than filaments. Ovaries pubescent, with equally long and oblong style added 2^{mm} long; ovule 1, erect. Fruit not present.

Platanillo on the road to Cañas Gordas, Costa Rica, alt. 3400^{ft}, Feb. 1897, *Pittier*, no. 11108 herb. nat. C. R.

Capparis discolor Donn. Sm. (§ CYNOPHALLA DC.)—Glabra. Folia in axilla eglandulosa lineari-oblonga utrinque acuta subtus candicantia et nervis venisque atris reticulata longepetiolata. Racemus terminalis sessilis, rhachi abbreviata, pedicellis longissimis. Sepala libera orbiculari-ovata a petalis oblongo-ovalibus 4-plo superata. Stamina toro conico insidentia, antheris linearibus. Ovarium gynophoro longius.

Leaves 10–14×2.5–3^{cm}, petioles 3–4.5^{cm} long. Raceme corymbiform, rachis about 1.5^{cm} long, pedicels about 10, 2.5–4.5^{cm} long. Sepals biserially imbricate, 5^{mm} long, obtuse. Petals 18–20^{mm} long, alternately somewhat broader, obtuse at each end, exunguiculate. Stamens indefinite, a third longer than petals, anthers 4^{mm} long. Torus 4-glandular. Ovary cylindrical, a half longer than gynophore. Fruit not present in the specimens.

Forest of Rodeo de Pacaca, Costa Rica, Jan. 1891, *Pittier*, no. 3537 herb. nat. C. R.

Norantea subsessilis Donn. Sm. (§ Cochliophyllum Delp. in Atti Soc. Ital. Sc. Nat. **12**: 181.)—(*Ruyschia? subsessilis* Benth. Bot. Voy. Sulph. 73.—*Noranteæ* species? Wittmack in Mart Fl. Bras. **12**^{1}: 248.)—Specimina Tonduziana tantum florigera cum hac specie phrasibus nimis brevibus descripta satis bene congruunt. Folia 8^{cm} longa 3^{cm} lata ad basin aequalem 1^{cm} lata glandulis uniserialibus e margine remotis utrinsecus circiter 10–12 notata, petiolis 2^{mm} longis. Racemus crassus usque ad 5^{cm}, pedicellis 5–6^{cm} longis in quinta vel sexta parte inferiori bractea pendula obovata 14^{mm} longa 8^{mm} lata cuculliformi atro-purpurea instructis. Prophylla calyci appressa sepaloidea. Sepala 5–6^{mm} longa, exteriora latiora quam longiora. Petala libera elliptica 1^{cm} longa per anthesin in massa decidua. Stamina circiter 13, antheris ovalibus 3^{mm} longis utrinque retusis quam filamenta complanata paulo brevioribus. Ovarium depresso-globosum 3^{mm} altum 5^{mm} latum striatum 3-loculare spurie septatum intus pubescens, stylo crasso 3^{mm} longo, stigmate subintegro. Ad *Noranteam Jussiaei* Tr. et Planch. accedit.

Páramos del'Abejonal, Costa Rica, alt. 5800^{ft}, Apr. 1893, *Tonduz*, no. 7897 herb. nat. C. R.

Malpighia dasycarpa Donn. Sm.—Folia juniora sparsim pilosa, adulta glabrata ovato-elliptica longe acuminata ad basin obtusa integra longiuscule petiolata, stipulis binis interpetiolaribus oblongo-ovatis. Corymbi axillares et terminales longissime pedunculati laxi, bracteis foliaceis, pedicellis brevissimis. Calyx 8-glandulosus. Petala breviter unguiculata. Filamentorum tubus partes liberas aequans. Ovarium hirsutum.

Younger leaves oblong-elliptical, at base acutish, canescent beneath on midrib and nerves, the older 15×7^{cm}, apex mucronulate; nerves 6–7 to the

side, prominent beneath; petioles 8–13^{mm} long; stipules canescent, 3–4^{mm} long, deciduous. Peduncles 4–6^{cm} long, bracts 1.5–3^{cm} long, primary axes 1–2.5^{cm} long, pedicels 4–5^{mm} long. Segments of calyx orbicular-ovate, 3^{mm} long, pubescent. Petals oval, with claw 2–3^{mm} long added 8–10^{mm} long, the interior one exceeding the others. Staminal tube 1^{mm} high, anthers 2^{mm} long. Ovary globose, 2^{mm} in diam., equaling the styles. Fruit not present.—Distinct by the ovary from all known species except *M. parvifolia* A. Juss.

Rio Samalá, Depart. Retalhuleu, Guat., alt. 1700^{ft}, Oct. 1891, *Shannon*, no. 217 Pl. Guat., etc., qu. ed. Donn. Sm. sub *M. glabra* L.?—Banks of Rio Torres, San Francisco de Guadalupe, Costa Rica, alt. 3400^{ft}, Nov. 1893, *Tonduz*, no. 8444 herb. nat. C. R.—San Juan del Norte, Nicaragua, June 1895, *Pittier*, no. 9653 herb. nat. C. R.

Malpighia edulis Donn. Sm.—Ramuli cum foliis subtus et inflorescentia ochraceo-tomentelli. Folia supra praeter costam nervosque glabrescentia elliptica utrinque praesertim superne acuminata hujus generis inter maxima. Umbelli axillares et terminales foliis multoties breviores, pedunculis petiolos paulo superantibus pedicellos 4–7-fasciculatos subaequantibus. Calyx 10-glandulosus. Petala trimorpha. Stamina inaequilonga.

Leaves 15–19×6–9^{cm}, petioles 8^{mm} long; stipules petiolar, subulate, 2–3^{mm} long. Peduncles 10–12^{mm} long; pedicels in middle articulated and bracteolate; bracteoles 2, oblong, 2^{mm} long. Segments of calyx tomentulose, oblong-ovate, 2^{mm} long. Inmost petal the largest, with claw 2^{mm} long added 1^{cm} long, oval, entire margin pectinate with a fringe 2–3^{mm} long; 3 interior petals more orbicular, pectinate on one side only; external petal pectinate only at its hastate-cordate base. Stamens alternately longer; the tube 1^{mm} high, shorter than the free portions of the longer filaments. Ovary glabrous, 3^{mm} high, equaling styles.—Nearest to *M. Mexicana* A. Juss.

Forest of La Carpintera, Costa Rica, Aug. 1891, *Pittier & Tonduz*, no 4394 herb. nat. C. R.—San Francisco Dos Rios. C. R., Aug. 1891, *Pittier*, no. 4409 herb. nat. C. R. Cultivated for its fruit. Popular name *Acerolla*.

BANISTERIA CORNIFOLIA Spreng., var. **discolor** Donn. Sm.—Folia subtus pube argenteo-sericea nitescentia. Paniculae floribundae folia superantes.

San Pedro de la Calabaza, Costa Rica, alt. 3300^{ft}, Oct. 1896, *Tonduz*, no. 10924 herb. nat. C. R.

Zanthoxylum ferrugineum Radlk. (EUZANTHOXYLUM Endl.; Tr. et Planch. in Ann. Sc. Nat. V. **14**: 308)—Arbor, ut videtur, inermis; ramuli ultimi in novellos florigeros lana ferruginea

obductos continuati glabrati, crassiusculi (diametro 7^{mm}), cortice plicato-rugoso cinereo; folia alterna, impari-pinnata, ad apices ramulorum conferta, novella ad petiolos rhachesque necnon subtus margineque et praesertim infima rudimentaria perulas pinnatilobas exhibentia lana densa ferruginea fugaci e pilis longiarticulatis pauciramosis vel fasciculato-stellatis contexta induta necnon, ut et adultiora, pilis albidis breviarticulatis in cellulam elongatam acutam terminatis aliisque unicellularibus adpresse adspersa, adulta (petiolo 4^{cm} longo adjecto circ. 24^{cm} longa, $10-12^{cm}$ lata) ad axillas exsudationes gummosas interdum foventas, rhachi nuda pubescente, stipulis nullis; foliola subopposita, 6-8-juga, membranacea, penninervia, ex ovato oblonga, intermedia majora (6.5^{cm} longa, 2.5^{cm} lata), acuta, basi inaequali subsessilia, margine hyalino subintegerrima, vix nisi inferiora paucicrenata, in sinubus glandula interna oleipara pellucida magna instructa, insuper subtus juxta nervum medianum hinc inde glandulis superficialibus scutatis (quas nectaria extranupitalia vocant) notata et glandulis parvis numerosissimis per staurenchyma et pneumatenchyma dissitis dense minutim pellucidopunctata, necnon glandulis lepidoideis parenchymaticis foveolis insidentibus (aegrius perspiciendis) supra subtusque adspersa, epidermide non mucigera; flores (masculi tantum suppetebant) in paniculas ad apices ramulorum inter folia novella ($6-10^{cm}$ longa) interjectas (subaequilongas) lanoso-pilosas densifloras corymboso-cymosas in polychasia capituliformia basi dichasia gerentia desinentes congesti, breviter pedicellati, pedicellis basi bracteolarum loco saepissime flores rudimentarios gerentibus; perianthii foliola 9-10, linearia ($2-3^{mm}$ longa), alia (plus minus conspicue exteriora et sepalis respondentia) breviora et angustiora, alia (subinteriora, reliquis subalterna) longiora et paullulo latiora, omnia tenuiter membranacea, flavidula, pilis glandulisque raris lepidoideis adspersa, glandulis internis punctata; staminum vestigia nulla; discus gynophorus brevis, glaber; pistillum monomerum, disco insidens (vix 3^{mm}); germen (1^{mm} vix superans) gibboso-obovatum, dorso convexum, ventre recto (floris partem posteriorem spectante) in stylum sublateralem (paullo longiorem) filiformem continuatum,

pilis furcatis vel fasciculato-stellatis tomentosum glandulisque lepidoideis tumide lenticularibus obsitum, intus glabrum; stylus basi pilis similibus, superne pilis eramosis unicellularibus puberulus, in stigma capitellatum terminatus; gemmulae in loculo supra mediam rhaphen ventralem duae, collateraliter suspensae, anatropae, epitropae (rhaphe ventrali, micropyle extus supera); fructus ignotus.

Near Alajuela, alt. 2700^{ft}, March 1896, *Donn. Sm.* no. 6468 Pl. Guat., etc., qu. ed. Donn. Sm.

Microtropis occidentalis LOES.— Glaberrima; ramulis oppositis, i. s. atro-brunneis, nitidis longitudinaliter striatis, $1–3^{mm}$ crassis; foliis oppositis, chartaceis, $8–10^{mm}$ longe petiolatis, integerrimis, basi cuneatis usque subobtusis, apice obtusiuscule et plus minus manifeste acuminatis, $6–13^{cm}$ longis, $2–5^{cm}$ latis, i. s. viridibus subtus pallidioribus, costa supra plana vel vix prominula, subtus subprominente, nervis lateralibus utrinque circ. 6 tenuissimis ad apicem versus curvatis, tenuissime et densiuscule reticulatis, supra vix prominulis, subtus tenuissime prominentibus; inflorescentiis in foliorum axillis solitariis plerumque bis dichotome furcatis, $6–12^{mm}$ longe pedunculatis, bracteis deltoideis, acutiusculis, subcarinatis, usque circ. 1^{mm} longis, pedicellis ultimis brevissimis; floribus sub anthesi circ. 3^{mm} diam., sepalis 4 vel plerumque 5 rotundatis inaequalibus, interioribus majoribus, ut bracteæ obscure marginatis et sub lente tenuiter fimbriatis, petalis 4–5 rotundatis albidis, staminibus 4–5 in disci 4–5-goni angulis insertis, vel, si vis, filamentis basi in discum 4–5-gonum dilatatis, sepalis oppositis et eis brevioribus, antheris parvis, cordiformibus, sterilibus, ovario tantum basi disco subimmersum, ceterum libero, conico in stylum brevem et crassiusculum angustato, incomplete 2-loculari, ovulis 4 placentae brevi centrali affixis, stigmate parvo capitellato; fructu capsulari, oblongo, apice breviter apiculato, uniloculari, circ. $12–13^{mm}$ longo, dehiscente (?), monospermo, semine e basi erecto, rugoso, testa arillam simulante, albumine parco et duro, embryone magno, cotyledonibus ovali-oblongis, viridibus.

Peraffinis *M. discolori* Wall., speciae Indicae, ut genus totum adhuc tan-

tum ex India orientali notum est. Illa vix nisi disco obsoletiore a nostra specie recedit. Plantam nostrae simillimam a Schiede in Mexico in Cumbre del Obispo lectam et propter flores nondum plane evolutos atque ob patriam plane extraordinariam adhuc indeterminatam in herbario regio Berolinensi inveni.

Volcán de Poas, alt. 8000ft., March 1896, *Donn. Sm.*, no. 6470 Pl. Guat., etc., qu. ed. Donn. Sm.

Luehea meiantha Donn. Sm. (§ POLYANTHAE Schumann in Mart. Fl. Bras. **12**^{3}**:** 152)—Folia discoloria elliptico- vel obovato-oblonga longe acuminata ad basin obtusam 3-nerviam inaequalia. Cymulae breviter pedunculatae, floribus minimis. Involucri bracteolae 3 oblongo-ellipticae 3-nerviae sub anthesi caducae pedicellis longiores sepalis linearibus dimidio breviores. Petala a sepalis 2–3-plo superata oblonga. Annulus barbatus staminodiis respondens. Stamina levissime coalita, antheris ellipticis. Ovarium trigonum 3-loculare.

Indument stellate, pale ochraceous. Leaves $16–22 \times 5–8.5^{cm}$, sparsely pubescent above, more densely beneath, and like panicles, involucre and calyx sometimes tomentulose; basal nerves disappearing in upper third part of leaf, the lateral arising above the middle and about 3 to the side, transverse veins parallel and somewhat remote; margin above middle slightly and distantly appressed-serrulate; petioles $1.5–2.5^{cm}$ long. Panicles axillary and terminal, subequaling leaves; bracteoles oblong-ovate, 3^{mm} long, reflexed, deciduous. Sepals $8–11 \times 1.5–2^{mm}$, acute, villous within. Petals roseate, 4×1^{mm}, abruptly contracted into a claw that is thickened within with an entire cuneate gland 1^{mm} long, densely barbate above gland. Gynophore 7^{mm} high. Annulus of staminodes 0.5^{mm} broad, the hairs 1^{mm} long. Stamens about 25, of unequal length, the longer a little shorter than sepals, like staminodes obscurely fasciculate in five groups, anthers 0.25^{mm} long. Ovary elongate-elliptical 2.5^{mm} long, twice exceeded by filiform style. Capsules not present.—Anomalous by staminodes, anthers and ovary.

Jiménez, Llanos de Santa Clara, Costa Rica, alt. 600ft, Sept. 1896, *Cooper*, nos. 10212 & 10850 herb. nat. C. R.

BURMEISTERA CYCLOSTIGMATA Donn. Sm., in BOT. GAZ. **20:** 291, var. **Suerrensis** Donn. Sm.—Folia oblongo-ovata aut ovato-lancelota, floralia ovata. Calycis dentes triangulares tubo 3-plo breviores.

Suerre, Llanos de Santa Clara, Costa Rica, alt. 900ft, Feb. 1896, *Donn. Sm.*, no. 6623 Pl. Guat., etc., qu. ed. Donn. Sm.

Vaccinium Poasanum Donn. Sm.—Glabrum. Folia brevipetiolata sempervirentia integerrima oblongo-elliptica, apice contracto et obtuse acuminato, basi cuneata. Racemi axillares foliis breviores, rhachi brevi, pedicellis paucis gracilibus flores aequantibus. Corollae campaniformis lobi brevissimi. Antherae muticae poro terminali dehiscentes, loculis quam filamenta brevioribus a tubulis 3-plo superatis. Bacca 5-locularis.

Shrub 2^{m} high. Leaves coriaceous, opaque, $5-7 \times 2-3^{cm}$, petioles $2-3^{mm}$ long. Rachis about 8^{mm} long; pedicels 4–5, erect, $10-14^{mm}$ long, bracteate at base, bibracteolate in middle; bracts and bracteoles scariose, triangular-linear, $2-3^{mm}$ long, aristulate, fusco-ciliate. Calyx turbinate, 4^{mm} long, limb mucronate. Corolla white, 1^{cm} long, 8^{mm} broad, not contracted above; lobes broad, acuminate, spreading. Stamens 10, epigynous, a little shorter than corolla; filaments free, villose, 3^{mm} long; anthers affixed above middle, cells 2×1^{mm}, slender tubes $6-7^{mm}$ long. Berry globose, $6-7^{mm}$ in diam., many-seeded, spurious dissepiments none.

Borders of the upper lake of Volcán Poas, Costa Rica, alt. 7800^{ft}, Mch. 1896, *Donn. Sm.*, no. 6634 Pl. Guat., etc., qu. ed. Donn. Sm.—Summit of Volcán Poas, alt. 8500^{ft}, Nov. 1896, *Tonduz*, no. 10783 herb. nat. C. R.

Ardisia auriculata Donn. Sm.—Glabra. Folia immaculata sessilia maxima obovato-oblonga in triente parte superiore acuminata deorsum in lobos amplexicaules angustata. Paniculae terminales geminae pyramidales amplae, ramis solitariis, pedicellis ad apicem versus ramorum secundariorium racemosis gracilibus. Calycis lobi ovati acuti. Bacca viridis grosse maculata.

Tree of medium size; branches smooth, pallid. Leaves entire, chartaceous, pellucid, impunctate, minutely lepidote beneath, 4^{dm} long, above middle 13^{cm} and at base 4^{cm} broad, round auricles 1^{cm} long; lateral nerves spreading, arcuate; pseudo-nerves 2, distinct, remote from margin. Panicles penduculate, scarcely exceeded by leaves, pedicels $6-10^{mm}$ long. Lobes of calyx 2^{mm} long, marked by oblong spots. Berry depressed-globose, $6-7^{mm}$ in diam. Flowers not present.

Forests of Suerre, Llanos de Santa Clara, Costa Rica, alt. 900^{ft}, Feb. 1896, *Donn. Sm.*, no. 6640 Pl. Guat., etc., qu. ed. Donn. Sm.

Ardisia stenophylla Donn. Sm.—Folia supra medium subcrenulata lineari-oblanceolata acuminata in petiolum brevem attenuata punctis et lineis pellucida, nervis primariis paucis.

Panicula terminalis sessilis foliis brevior laxiflora, pedicellis ad apicem versus ramorum primariorum alternorum racemoso-fasciculatis gracilibus. Alabastra lanceolato-ovoidea. Laciniae calycinae et corollinae subsejunctae, hae quam illae altero tanto longiores. Antherae trigono-lineares, filamentis in tubum brevissimum omnino connatis.

Arboreous. Everywhere glabrous except the ciliolate calyx. Leaves crowded toward end of branchlets $14–18 \times 3–3.5^{cm}$, chartaceous, midrib prominent above, less conspicuous beneath; primary lateral nerves remote, about 10, arcuate, long-ascending; petioles $5–7^{mm}$ long. Panicle $6–9^{cm}$ long; branches spreading, $2–3^{cm}$ long; pedicels $9–12^{mm}$ long. Alabastra 6^{mm} long. Flowers punctate. Segments of calyx 3-nerved, lanceolate, 2.5^{mm} long, spreading before anthesis. Segments of corolla white, oblong, acute. Anthers 5^{mm} long, acute. Ovary oval, 1^{mm} long, produced into style ancipital below and equaling stamens. Berries not present.

Small tree, forests of Shirores, Talamanca, Costa Rica, alt. 300^{ft}, Feb. 1895, *Pitt. & Tond.*, no. 9173 herb. nat. C. R.—Forests of Tsâki, Talamanca, alt. 600^{ft}, Aug. 1895, *Tonduz*, no. 9586 herb. nat. C. R.

Forestiera Cartaginensis Donn. Sm.—Glabrata. Folia coriacea ovato-elliptica utrinque acuminata integra aut supra medium grosse serrata rectinervia, margine revoluto. Racemorum pedicella 5–7 plerumque oppositi. Drupa dimidiato-elliptica laciniis calycinis lineari-lanceolatis minutis suffulta, putamine striato.

Arboreous, $5–7^{m}$ high, branchlets rigid, the younger pubescent. Leaves not porulose, pubescent beneath on midrib, $5–7 \times 2–4^{cm}$, narrowed to canaliculate petiole $4–6^{mm}$ long. Scales of leaf buds pluri-imbricate, triangular-ovate, 2^{mm} long, ciliate. Rhachis of fruiting racemes $9–12^{mm}$ long, pedicels $3–4^{mm}$ long. Segments of calyx 1^{mm} long, ciliolate. Drupe $8–9^{mm}$ long, arcuate on one side, straight on the other; crowned with persistent style 1^{mm} long, 1-seeded, putamen lignose. Flowers not present. Approaching *F. racemosa* Watson by inflorescence, and *F. porulosa* Poir. by drupes; this species differs from both by its foliage.

Cartago, Costa Rica, alt. 4600^{ft}, Dec. 1887, *Cooper*, no. 5849 Pl. Guat., etc., qu. ed. Donn. Sm.—Slopes below San Rafael de Cartago, C. R., alt. 5100^{ft} Oct. 1894, *Pittier*, no. 9028 herb. nat. C. R.

Tabernaemontana Alfari Donn. Sm. (§ TABERNA a Miers pro genere proposita)—Folia breviter petiolata membranacea pellucida minute reticulata oblongo-elliptica caudato-acuminata ad imam basin acuta saepe in eodem jugo dimorpha. Cymae e

dichotomiis singulae aut binae brevissimae subtriflorae. Calycis parvi paucisquamuliferi lobi orbiculati nervosi. Corollae luteæ tubus calyce 12-ies longior paulo infra medium staminiferus et contortus. Carpella ovato-lanceolata disco usque ad ⅓ adnata.

Arboreous, 3–4^{m} high, glabrous throughout, abounding in resinous juices. The larger leaves in the pair 8–11 × 3.5–5^{cm}, abruptly prolonged into a tip 1^{cm} long; the smaller ovate 3–4 × 2–2.5^{cm}; all subsessile and with about 10 spreading nerves to the side. Cymes about 1^{cm} long, bracteose; pedicels scarcely longer than calyx and incrassate beneath the flower. Segments of deeply partite calyx 3^{mm} long, 1–5-squamuliferous, some of them occasionally naked. Tube of corolla 3.5^{cm} long, 4^{mm} wide in middle, subampliate at throat, twice exceeding the 1^{cm} broad segments, pubescent between the stamens. Anthers sessile, 6^{mm} long. Disk stout, 1^{mm} high. Follicles not seen.— Nearest to *Taberna disparifolia* Miers.— Named for Sr. Don Anastasio Alfaro, Secretary of the National Museum of Costa Rica, in memory of kind services while his guest at Suerre.

Forests of Suerre, Llanuras de Santa Clara, C. R., alt. 900^{ft}, Apr. 1896, *Donn. Sm.*, no. 6648 Pl. Guat., etc., qu. ed. Donn. Sm.— Limoncito y Vuelta, Cañas Gordas, C. R., alt. 3400^{ft}, Feb. 1897, *Pittier*, no. 11094 herb. nat. C. R.— Forests of River Naranjo, C. R., alt. 600–800^{ft}, March 1893, *Tonduz*, no. 7645 herb. nat. C. R.

Tabernaemontana Donnellsmithii Rose, var. **Costaricensis** Donn. Sm.— Folliculi verrucosi ovales acuminati.

Borders of Rio Toro, Amarillo, Llanos de Santa Clara, C. R., alt. 1000^{ft}, Apr. 1896, *Donn. Sm.*, no. 6646 Pl. Guat., etc., qu. ed. Donn. Sm.

Tabernaemontana longipes Donn. Sm.— Folia magna obovato- aut elliptica-oblonga in acumen subito producta deorsum attenuata. Cymae longissime pedunculatae folia fere aequantes repetitus dichotomae floribundae. Calycis lobi ovati squamulis 5 muniti. Corollae tubus ad basin ampliatus calyce 3-plo longior segmentis elongato-acuminatis triente brevior ad medium staminiferus. Discus subnullus. Carpella ovata acuta.

Epiphytal, glabrous, branchlets compressed toward their tips. Leaves 20–26×7–9^{cm}, chartaceous, shining, dots and veins pellucid; nerves chiefly opposite, 12–15 to the side, spreading and ascending arcuately to the margin, like the broad midrib complanate and fuscous on lower side of leaf; petioles 2–2.5^{cm} long, dilated at base, subconnate. Peduncles geminate in the forks, 10–22^{cm} long, cymes diffuse, primary axes 3–6^{cm} long, pedicels 5–10^{mm} long;

bracteoles ovate, 1–2^{mm} long. Lobes of calyx 2.5^{mm} long, obtuse, margins hyaline, squamules subulate. Corolla white; tube cylindrical, dilated above middle, narrower than the oblong-ovoid bud of the segments, pubescent below the stamens; segments 10–12^{mm} long, dolabriform, abruptly acuminate. Anthers included, blue, 3^{mm} long. Style 3–5^{mm} long; stigma annulate below, 5 angulate above. Follicles not present.—Related to *T. citrifolia* Jacq. by structure of flowers, but differing by foliage, inflorescence, and insertion of stamens.

Hacienda de La Concepción, Llanuras de S. Clara, Costa Rica, alt. 600^{ft}, Feb. 1896, *Donn. Sm.*, no. 6650 Pl. Guat., etc., qu. ed. Donn. Sm.

FISCHERIA MARTIANA Decne., var. **funebris** Donn. Sm.—Fusco-hirsuta. Segmenta calycina glandulosa linearia 1^{cm} longa corollinis planis longiora.

Chilamate, borders of Rio Sarapiqui, Costa Rica, Feb. 1893, *Biolley*, no. 7385 herb. nat. C. R.—Forests of Santo Domingo de Golfo Dulce, C. R., Mch. 1896, *Tonduz*, no. 9936 herb. nat. C. R.

ERYTHRAEA STRICTA Schlecht., var. **tereticaulis** Donn. Sm.—Caulis sicut inflorescentiae axes teres. Flores tetrameri quam ei plantae typicae majores.

Uncultivated grounds at Surubres near San Mateo, Costa Rica, *Biolley*, no. 7076 herb. nat. C. R.

BALTIMORE, MD.

THE RELATION OF NUTRIENT SALTS TO TURGOR.

EDWIN BINGHAM COPELAND.

INTRODUCTORY.

IT is now about twenty years since turgor stepped into a prominent place in vegetable physiology. At almost the same time Pfeffer[1] demonstrated the previously unsuspected heights attained by osmotic pressure, and de Vries[2] applied it to the dark problem of the dynamics of growth. The new discovery proved a scientific gold field and turgor was immediately invoked as the solvent of a variety of problems where more familiar agencies had been found inadequate. The exaggerated importance ascribed to it in growth endured almost to the present day, when the experiments of de Vries,[3] Wieler,[4] Stange,[5] Hegler,[6] Pfeffer,[7] Schwendener and Krabbe,[8] Kolkwitz,[9] and Copeland[10] have shown that it cannot supply the energy necessary for growth (Pfeffer), that growth can occur without turgor stretching (Pfeffer, Kolkwitz), and that abnormally slow growth is more

[1] Osmotische Untersuchungen. 1877.

[2] Untersuchungen über die mechanischen Ursachen der Zellstreckung. Leipzig. 1877.

[3] Eine Methode zur Analyse der Turgorkraft. Jahrb f. wiss. Botanik **14**: 427. See also page 561.

[4] Berichte d. deutschen bot. Gesell. **5**: 375. 1887.

[5] Beziehungen zwischen Substratconcentration, Turgor, und Wachsthum bei einigen phanerogamen Pflanzen. Bot. Zeit. **50**: 253. 1892.

[6] Über den Einfluss des mechanischen Zugs auf das Wachsthum der Pflanze. Beiträge zur Biologie d. Pflanze **6**: 382. 1893.

[7] Druck- u. Arbeitsleistung durch wachsende Pflanzen. Leipzig. 1893.

[8] Über die Beziehungen zwischen dem Maass der Turgordehnung und der Geschwindigkeit der Längenzunahme wachsender Organe. Jahrb. für wiss. Botanik **25**: 323.

[9] Untersuchungen über Plasmolyse, Elasticität, Dehnung, und Wachsthum, an lebendem Markgewebe. Fünfstück's Beiträge. 1895.

[10] Über den Einfluss von Licht und Temperatur auf den Turgor. Halle a. S. 1896.

likely to increase, and abnormally rapid growth to decrease the turgor, than to be caused by variation in the latter.

In Stange's work, the substratum was merely a physical agent of varying concentration. But few salts were used, and no essential difference was observed in their action. Beyond a suggestion by Benecke [11], that the turgor may be caused by the presence of sodium as well as by that of potassium, and that the continual acquisition of the former probably serves such "secondary" functions, the relation between the chemical nature of the substratum and the turgor has never been considered. To assist in clearing this untrodden field, my investigation was undertaken.

It was hoped in beginning this study that a considerable number of chemical elements would be made to show some direct influence on turgor. But as the tables well show, this hope was not realized. With the exception of potassium, and in one case, perhaps of NO_3, the removal of any food constituent did not tend to depress the turgor, or if it did, it stopped the growth so quickly and effectively that the turgor rose. Failure to get evidence on the question in hand is then added support for the thesis already referred to,[12] that growth regulates turgor more decidedly than turgor growth.

Methods.—All the plants used as subjects of experiment were grown in water culture, in glass jars, protected from the light by heavy drying paper. The covers of the jars were wood, bored nearly through with a large auger, the rest of the way with a small one, furnishing an excellent support for the seeds. The jars for most of the experiments were of a little less than three liters capacity, larger ones of eight liters being sometimes used. During the time that the experiments lasted,

[11] Ein Beitrag zur mineralischen Nahrung der Pflanzen. Berichte d. deutschen bot. Gesell. 1894. Generalversammlung, p. 114. "Es ist absolut nicht einzusehen, warum nicht in solchen Leistungen, die weniger eng an vitale Functionen gekettet, mehr als formale Bedingungen des Lebens aufzufassen sind—nahe liegt es hier, z. B. an osmotische Leistungen zu denken—z. B. Natriummolekel für das Kalium einspringen könnten.

[12] Copeland, loc. cit.

the larger size seemed unnecessary, and was much less convenient. The seeds were germinated in clean sawdust, and when the radicles were a few centimeters in length, average specimens were selected from a large number, placed in the culture jars, and plugged fast with cotton. When the duration of the experiment demanded it, the solutions were renewed, but in many cases it sufficed to keep the jars full by occasional addition of distilled water.

The first solutions were prepared according to de Vries' isotonic coefficients[13]: afterward they were made according to molecular equivalents. The latter is the more scientific plan, but does not differ enough to affect the results. All salts used were of absolute purity, and the utmost care was taken that the concentration was exactly that stated: for instance, in making up $MgSO_4$ solution all dehydrated crystals were removed individually before the salt was weighed; and such compounds as $Ca(NO_3)_2$, which cannot well be weighed dry, were made in solution synthetically by the writer. Clarke's atomic weight determinations were used. Making up the solutions by exact molecular equivalents secured as nearly as was possible their osmotic equality. For the individual salts, in solution alone, this might have been accomplished more accurately by taking into account their varying degrees of dissociation. But as the opportunity for unavoidable and unseen breaking up and reformation of molecules in such dilute solutions is limited only by the variety of salts dissolved, there is no way of determining the salts whose dissociation should be reckoned with. At any rate, in solutions so dilute as those used dissociation of all nutrient salts is very complete, and in practice may be regarded as quite so.

The turgor was determined by the usual method, *i. e.*, by immersing sections in a sequence of solutions of known strength of KNO_3. In the experience of the writer, no other solvent has proved itself so available for this purpose as saltpeter. It is easily and accurately prepared, keeps well, diffuses quickly

[13] Op. cit.

through the plant, and is harmless for any reasonable duration of experiment. It has, however, one theoretical disadvantage which has hitherto been overlooked, namely that, like any other crystalline salt, it dissociates in solution, and to an increasing extent with progressive dilution. Any given solution is then a little more than half as strong osmotically as one with twice the weight of dissolved saltpeter.[14] This objection might be overcome by making solutions according to the osmotic instead of per cent. strength, but since this source of error is less than that arising from the inaccuracy of the tests and the individual variations of the plants and the cells, and the correction at best would only be relative, it seemed best to conform to the established method. In the reports of the experiments the expression "turgor = 2.5 per cent." means that 2.5 per cent. KNO_3 is just sufficient to begin plasmolysis.

THE EXPERIMENTS.

Phaseolus multiflorus. Two series of cultures were carried through. The complete or standard "normal" solution was made by mixing, and diluting to one-twentieth, equal parts of the following solutions, prepared according to de Vries' isotonic coefficients:

$Ca(NO_3)_2$	9.876 %	isotonic to	0.8 æq. KNO_3
KNO_3	2.525 %	or	0.25 æq.
NaCl	1.462 %	isotonic to	0.25 æq. KNO_3
K_2HPO_4	2.597 %	" "	0.25 æq. KNO_3
$MgSO_4$	4.464 %	" "	0.25 æq. KNO_3

A. Put in cultures November 23. Radicles 3–5^{cm} long.

1. In normal solution.

		Nov. 28	Jan. 5	Feb. 13
Stem	length	11^{cm}	50^{cm}	50^{cm}
	turgor	2.5 %	2.5–3 %	2.5–3 %
Root	length	10^{cm}	——	55^{cm}
	turgor	2–2.5 %	2 %	2 %

[14] A 5 per cent. solution is only 4.67 times as strong osmotically as a 1 per cent. solution. Kohlrausch, Wied. Ann. **26**: 195.

2. In distilled water.

Stem	length	5^{cm}	33^{cm}	mostly dead.
	turgor	2–2.5 %	3 %	3 %
Root	length	6.5^{cm}	——	dead.
	turgor	2 %	2 %	

3. With $NaNO_3$ and Na_2HPO_4 instead of KNO_3 and K_2HPO_4, in equivalent quantities.

Stem	length	9^{cm}	50^{cm}	44^{cm}
	turgor	2.5 %	2 %	2 %
Root	length	9.5^{cm}	——	20^{cm}
	turgor	2.5 %	1.5–2 %	1.5 %

The solutions were renewed once during the experiment, and at its close the plants in complete solution were growing nicely. The plants tested January 5 were the largest in all the jars.

B. Put in water cultures November 30.

1. Normal.

		Dec. 17	Jan. 12	Jan. 25 (Temp. down to 10°C.
Stem	length	26^{cm}	42^{cm}	45^{cm}
	turgor	2.5 %	2.5–3 %	3–3.5 %
Root	length	19^{cm}	——	——
	turgor	2–2.5 %	2 %	2.5 %

2. Distilled H_2O.

Stem	length	7^{cm}	19^{cm}	——
	turgor	2–2.5 %	2.5–3 %	2.5 %
Root	length	6^{cm}	8^{cm}	——
	turgor	2 %	1.5 %	2 %

3. Na instead of K.

Stem	length	30^{cm}	52^{cm}	65^{cm}
	turgor	2 %	2 %	2.5 %?
Root	length	19^{cm}	——	nearly dead.
	turgor	2 %	1.5 %	2 %

4. With $CaCl_2$ and KCl instead of $Ca(NO_3)_2$ and KNO_3.

Stem	length	20^{cm}	dead.
	turgor	2.5 %	
Root	length	14^{cm}	——
	turgor	2 %	2 %

5. With $NaNO_3$ instead of $Ca(NO_3)_2$ ("isotonic" quantities).

Stem	length	25^{cm}	26^{cm}	29^{cm}
	turgor	2.5 %	3 %	3 %
Root	length	18^{cm}	——	22^{cm}
	turgor	2 %	2 %	2–2.5 %

The beans without K flourished as well as those with it until almost the end of the experiment. As the plants become older and irregularly branched, and in many cases the main root dies and is replaced by branches, the length ceases to be a measure of the growth. But wherever it was any fair test it is included in the tables, so that the unquestionable influence of the growth on the turgor may be apparent. The cotyledons of seedlings in the last two cultures (4 and 5) were emptied more slowly than those of the others, which would tend to keep down the turgor of the growing parts. Occasional tests of the leaves of 1 and 3 showed their turgor to agree at about 3.5 per cent.

Phaseolus vulgaris. Seedlings put in the solutions December 9.

1. Normal.

		Jan. 9	Jan. 18	Jan. 27	Feb. 27
Stem	length	19^{cm}	23^{cm}		
	turgor	2.5 %	2–2.5 %	3 %	3 %
Root	length	9^{cm}	10^{cm}		
	turgor	2 %	1.5–2 %	2 %	2 %

2. Distilled H_2O.

Stem	length	10^{cm}	(tip dead)	dead.
	turgor	2.5–3 %	2.5–3 %	
Root	length	8^{cm}	8^{cm}	dead.
	turgor	2 %	2 %	

3. Na instead of K.

Stem	length	19^{cm}	25^{cm}	27^{cm}	
	turgor	2 %	2–2.5 %	2.5 %	2.5–3 %
Root	length	19^{cm}	22^{cm}		
	turgor	1.5 %	1.5–2 %	1.5 %	2 %

4. Cl instead of NO_3.

Stem	length	16^{cm}	17^{cm}	
	turgor	2–2.5 %	2.5 %	2.5–3 %
Root	length	10^{cm}	12^{cm}	dead.
	turgor	2 %	2 %	

5. Na instead of Ca.

Stem	length	12^{cm}	14^{cm}	16^{cm}	dead.
	turgor	2.5%	2.5%	2.5–3%	
Root	length	5^{cm}	7^{cm}	10^{cm}	dead.
	turgor	2%	2%	2%	

The leaves of 1, 3, and 5 were tested January 18, and all plasmolyzed in 3.5 per cent. The plants in the complete culture were of unhealthy appearance January 27, the leaves being spotted with brown dry flecks, and the roots short and bushy. Culture 3 showed the same symptoms in milder form. The solutions were poured off and replaced with others prepared from fresh salts (see below under Pisum for composition), and a better condition ensued. The seedlings in NO_3-free solution bore very empty and colorless roots, which soon rotted; while those deprived of Ca, though dwarfed, were rugged and hardy in appearance. The power of the Leguminosæ to endure want of K better than that of Ca[15] was well illustrated by both species of Phaseolus.

Pisum sativum. Placed in solution March 13. The normal solution used in this and most of the following experiments was:

$Ca(NO_3)_2$,	0.006 æq.
KCl,	0.0025 æq.
K_2HPO_4,	0.0015 æq.
$MgSO_4$,	0.0025 æq.

With a trace of ferric chloride in the jars, as needed.

The course of turgor and growth was:

1. Normal.

		March 27	April 13	May 4
Stem	length	34^{cm}	37^{cm}	
	turgor	2.5%	3%	2.5%
Root	length	25^{cm}	26^{cm}	
	turgor	2%	1.5–2%	2%

2. Distilled water.

Stem	length	22^{cm}	30^{cm}	
	turgor	2%	2%	2%
Root	length	12^{cm}	25^{cm}	
	turgor	2%	1–1.5%	1.5%

[15] Cf. Koenig u. E. Haselhoff: Die Aufnahme der Nährstoffe aus dem Boden durch die Pflanzen. Landw. Jahrb. **23**: 1009.

3. KCl and K_2HPO_4 replaced by equivalent quantities of NaCl and Na_2HPO_4.

Stem	length	27^{cm}	34^{cm}	
	turgor	2–2.5%	2.5%	2.5%
Root	length	23^{cm}	29^{cm}	
	turgor	1.5–2%	1.5%	1.5%

4. $CaSO_4$ instead of $Ca(NO_3)_2$.

Stem	length	26^{cm}	35^{cm}	
	turgor	2.5%	2.5–3%	2.5–3%
Root	length	26^{cm}	26^{cm}	
	turgor	2%	2%	2%

The substitution of $CaSO_4$ for its molecular equivalent $Ca(NO_3)_2$ involves a slight reduction of the osmotic power of the solution. This, taken alone, would tend to lower the turgor (Stange), but it was unable to make itself felt in the result, for the turgor of these stems (4) was the highest in any solution at the close of the experiment.

Sinapis alba. Seedlings were placed in solution, such as were used for Phaseolus, December 9. This plant is not adapted to water culture, and the specimems were never vigorous, though none of them in 1 or 3 died during the experiment.

1. Normal.

		Dec. 21	Jan. 23	Feb. 8
Stem	length	5^{cm}	5.5^{cm}	7^{cm}
	turgor	3%	3%	4%

2. Distilled H_2O.

Stem	length	4^{cm}	dead	
	turgor	2%		

3. Na instead of K.

Stem	length	4.5^{cm}	5^{cm}	5.5^{cm}
	turgor	2%	2.5%	3%

The roots were stunted from the start, and the unusual height of the turgor of the stems may have been due to the accumulation of food, at least in part. But starch was present in 3, as well as in 1, so that their difference in turgor (1 per cent. at the close of the experiment) must be referred to the effect of the presence or absence of K, for a reasonably definite

and not too unequal quantity of sugar must have preceded the formation of starch in both cases.

Fagopyrum, the Japanese buckwheat. The normal culture was like that used for Pisum. In the table, which in this case is a compilation, the length of the parts is omitted. In relative thriftiness in the different solutions the plants agreed quite well with those grown by Nobbe[16] in his classic work on the plant's need of potassium. The time is measured from the dates when the seeds were put in water culture.

1. Normal.

	After 9 days	After 19 days	After 33 days	After 42 days	After 57 days
Stem	2–2.5%	2–2.5%	2.5%	2.5%	2.5–3%
Root	2%	2%	2%	2%	

2. Distilled H_2O.

Stem	1.5%	2%	2%		
Root	1.5%	1.5%	1–1.5%		

3. Na instead of K.

Stem	2%	2%	2%	2%	2–2.5%
Root	1.5%	1.5–2%	1.5%	1.5%	

4. $Ca(NO_3)_2$ replaced by $CaSO_4$.

Stem		1.5–2%	2%	2%	
Root		1.5%	1.5–2%		

5. $Ca(NO_3)_2$ replaced by $NaNO_3$.

Stem	2–2.5%	2.5%	2.5–3%	3%	3%
Root	2%	2%	2%		

6. $MgSO_4$ replaced by $MgCl_2$

Stem	2.5%	2.5%	3%	3.5%	
Root	2%	2–2.5%	2–2.5%		

7. $MgSO_4$ replaced by $CaSO_4$

Stem		2.5%	3%		
Root		2–2.5%	2–2.5%?		

8. K_2HPO_4 replaced by K_2SO_4.

Stem		2.5%	3–3.5%	3.5%	
Root		2%	2–2.5%		

With the substitution of $MgCl_2$ for $MgSO_4$ occurred a small increase in the osmotic power of the solution, which, however,

[16] F. Nobbe, Landw. Versuchsst. 13 : 369.

cannot suffice to explain the very high turgor of the plants grown in it (6). When $Ca(NO_3)_2$ was replaced by $CaSO_4$ the osmotic power was reduced, but here, too, the turgor surpassed the normal.

The results given in this table tally very well with those obtained on Phaseolus, Pisum, and Sinapis, as far as the latter were carried out, the only difference being in the low turgor of buckwheat grown in cultures free of nitrates. In another series the turgor of the stems grown in nitrate-free cultures rose to 2–2.5 per cent., while in normal stems it was 2.5 per cent., both tested before there was any marked difference in growth. It certainly looks as though the turgor fell because the nitrates were absent, but no such tendency could be detected in any plant tested except the buckwheat. The turgor of 5 was distinctly higher than that of 1 before any difference was noticeable in their growth. The last three cultures (6, 7, and 8) were stunted in growth by the end of the second week, which explains their extreme turgor.

Zea Mays. Two series of cultures were carried through. For the first, dating from January 16, the cultures were made as described under Phaseolus.

		Feb. 6	Feb. 18	March 6	March 13	April 13
1. Normal.						
Stem	turgor	2.5%	2.5%	3%	3–3.5%	
Root	length	36cm	48cm	60cm	60cm	
	turgor	2%	2%	2%	2–2.5%	
2. Distilled H_2O.						
Stem	turgor	1.5–2%	2–2.5%	1.5–2%	1.5%	1.5–2%
Root	length	29cm	34cm	47cm		50cm
	turgor	1.5%	1.5%	1–1.5%	1.5%	1–1.5%
3. K replaced by Na.						
Stem	turgor	2%	2–2.5%	2.5%	2.5%	
Root	length	32cm	38cm	41cm	43cm	
	turgor	1.5–2%	2%	2%	1.5–2%	
4. Ca replaced by Na.						
Stem	turgor	3%	3%	3.5%	dead	
Root	length	34cm	36cm	54cm	dead	
	turgor	2%	2%	2–2.5%		

The normal solution for the second series, beginning March 11, was that given under *Pisum sativum*.

1. Normal.

		Mar. 22	Apr. 2	Apr. 21	May 5	June 11
Stem	length	22^{cm}	35^{cm}	52^{cm}	75^{cm}	85^{cm}
	turgor	2%	2%	2%	2.5%	3%
Root	length	36^{cm}	41^{cm}	66^{cm}		76^{cm}
	turgor	2%	1.5–2%	2%	1.5–2%	2%

1a. Containing 0.01 æq. instead of 0.0025 æq. $MgSO_4$.

Stem	length	21^{cm}	34^{cm}	50^{cm}	61^{cm}	dead.
	turgor	2%	2.5%	2.5%	2.5–3%	
Root	length	31^{cm}	34^{cm}	41^{cm}	47^{cm}	dead.
	turgor	2%	2%	2%	2%	

2. Distilled H_2O.

Stem	length	17^{cm}	26^{cm}	32^{cm}	34^{cm}	35^{cm}
	turgor	1.5–2%	1.5%	1.5%	1.5%	2.5% ?
Root	length	46^{cm}	75^{cm}	80^{cm}	85^{cm}	unsound
	turgor	1.5%	1–1.5%	1–1.5%	1.5%	1.5–2%

3. K replaced by Na.

Stem	length	20^{cm}	26^{cm}	32^{cm}	32^{cm}	dead ?
	turgor	1.5–2%	1.5%	1.5–2%	1.5%	
Root	length	34^{cm}	45^{cm}	54^{cm}	56^{cm}	dead.
	turgor	1.5%	1.5%	1.5%	1.5%	

3a. KCl replaced by NaCl.

Stem	length	19^{cm}	28^{cm}	37^{cm}		
	turgor	1.5–2%	2%	2%	2%	2.5–3%
Root	length	26^{cm}	35^{cm}	43^{cm}		
	turgor	1.5–2%	1.5–2%	1.5–2%	1.5%	2%

3b. K_2HPO_4 replaced by Na_2HPO_4.

Stem	length	21^{cm}	31^{cm}	44^{cm}	50^{cm}	
	turgor	1.5–2%	2%	2–2.5%	2–2.5%	2.5–3%
Root	length	30^{cm}	39^{cm}	50^{cm}		
	turgor	1.5–2%	2%	2%	2%	2%

3c. 0.005 æq. instead of 0.0025 æq. KCl: 0.003 æq. instead of 0.0015 æq K_2HPO_4

Stem	length	20^{cm}	28^{cm}	41^{cm}	51^{cm}	
	turgor	1.5–2%	2.5%	2.5–3%	2.5%	3%
Root	length	36^{cm}	40^{cm}	64^{cm}		
	turgor	1.5–2%	1.5–2%	2%	1.5–2%	2%

4. $CaSO_4$ instead of $Ca(No_3)_2$.

Stem	length	21^{cm}	30^{cm}	34^{cm}	40^{cm}
	turgor	2%	2–2.5%	2.5%	3–3.5%
Root	length	40^{cm}	52^{cm}	103^{cm}	110^{cm}
	turgor	1.5–2%	2%	1.5–2%	2%

5. K_2SO_4 instead of K_2HPO_4.

Stem	length	24^{cm}	34^{cm}	41^{cm}	47^{cm}	
	turgor	2%	2%	2.5%	3%	3.5%
Root	length	31^{cm}	38^{cm}	67^{cm}	85^{cm}	
	turgor	2%	2%	2%	2%	2–2.5%

In measuring the "stem" (Spross) the average height of the longest leaves of all the plants in the culture was taken, hence the growth appears to have been more uniform than in any of the preceding tables, in which the length is computed only from the plants used at each time for the tests. The turgor of the "stem" (Stengel) was determined in the upper part of one of the older internodes, at a point where growth was assumed to have ceased.

The difference in turgor between 1 and 1a would probably have been produced by the addition of the same quantity (0.0075 æq.) of any harmless salt, the action being probably purely physical. The cultures 3, 3a, 3b, and 1 form a series in which the K gradually increases without any change in the osmotic strength. The result shows a strikingly uniform gradation in both growth and turgor. Up to about the point of the normal solution an increase in the relative amount of K present was certainly beneficial to the plants, but doubling the K then present (3c) may not have had any more effect on the growth, or the turgor, than the addition of the same quantity of another salt (compare 1a). At the close of the experiment the only thrifty plants were in cultures 1 and 3c. All the plants in 1a, 3, and 4 were dead, and those in 3a and 3b had only the younger leaves and roots still making a feeble show of life.

CONCLUSIONS.

The testimony of the different experiments is so uniform, and the conclusions to be drawn are so simple and manifest,

that they have been reserved for discussion until after all of the tables have been presented.

1. Potassium presented in solution to the roots of plants causes the cells of both root and stem to exhibit a higher turgor than they can do when it is replaced by sodium. There is no conceivable reason for suspecting the Na of depressing the turgor; in fact the "normal" solution in some experiments contained Na, and in others did not, without any difference appearing in the results. So we may state it, that *potassium is a factor*, direct or indirect, *in the turgor of the plant.*

2. *There is no experimental ground for attaching this significance to any other constituent of the mineral food.*[17]

It need hardly be stated here that, in common with any molecule of any kind dissolved in the cell sap, the elements if present in solution must contribute to the turgor. Nor is it impossible that they are sometimes important factors in it; but if they are, our methods cannot demonstrate it. In some instances, as when plants in an incomplete solution are able for a time to grow normally and to maintain at least a normal degree of turgor, we can say decidedly that their presence does not contribute to the turgor. Fagopyrum and Zea grown without Ca, and Zea without HPO_4 illustrate the case against these two food elements. Again, when in the absence of some food constituent the depressed growth was able to produce a very high turgor, it is improbable that the substance in question is ever a considerable part of the plant's osmotically active matter. HPO_4, Mg, and SO_4 are such substances, whose absence was accompanied by low growth and high turgor. When the absence of K, on the other hand, stunted the growth (compare 1 and 3 of Zea) the turgor still remained low.

The behavior of the various plants grown in distilled water is worthy of more than the passing notice it can here receive. Many plants will grow very rapidly in pure water until their stored-up food is exhausted. In consequence at once of the rapid growth and of the want of nourishment they have a low tur-

[17] The food product of assimilation might usually be added to this list.

gor which must remain low even when their growth stops before death. But in other cases they fall behind their better fed rivals while their reserve food is still far from used up, as though the distilled water were in itself an active agent in restricting growth, and the turgor of these plants not uncommonly becomes as high as that of those normally grown (*Phaseolus vulgaris*). Such seedlings will sometimes become accustomed to the water, and after once ceasing to elongate will put forth a luxuriant new growth. As a sample of a number of similar cases a seedling of Zea may serve, whose roots were 13^{cm} long February 10; February 19 they were still 13^{cm}; but a week later they began to grow, and by March 10 measured 30^{cm}. The roots of the first growth were remarkably thick and coarse, and but little branched; the later ones almost capillary and mesh-forming.

Except for a few plants, and a very few salts, the growth of plants in water cultures has never been studied, and will well repay a comprehensive, painstaking, comparative investigation.

Is the influence of K upon the turgor a direct one? That is, does the K itself enter into the cell sap, in whatever combination, in such quantity as to be a considerable part of the matter in solution there, and is Na unable to replace the K in this physical function? Or is it by its activity in the protoplasm that K regulates the accumulation of other substances in the sap, in which respect Na, relatively inert and unessential to the plant, could not be expected to be equally effective? At first sight, especially as K is held to play a prominent part in both the production and the translocation of the carbohydrates, one is inclined to regard the indirect course as the true one. To settle the question, seedlings of *Phaseolus multiflorus* were put into water cultures in two ten-liter jars, one containing the normal mixture of $Ca(NO_3)_2$, KCl, K_2HPO_4, and $MgSO_4$, already given under Pisum, the other different only in the substitution of Na for K. The jars were kept nearly full by addition of distilled water until June 3, during which interval the K fed plants transpired about three liters more water than did the others. The "crop" was then harvested, the roots quickly dried with filter paper,

the leaves and younger growing stems removed, and the stems and roots separated and bottled. The average turgor at the time was:

In K solution: roots, 1.9%; stems, 3.6%.
In Na solution: roots, 1.6%; stems, 2.9%.

The excess of turgor in the K plants was then about 0.3% in the roots, and 0.7% in the stems. Abundant starch was present in all the stems of both cultures. By throwing away the leaves and youngest internodes, and separating the stems and roots, material was obtained for each analysis whose turgor was known and uniform. Seedlings of *Zea Mays* were grown in the same way from April 10 until June 12. Two of the K and several of the Na plants were then dead. The roots, especially of the latter, were in bad condition, while those grown with K were very thrifty. All dead parts and the blades of the leaves were removed, and the stems and roots separated and bottled. The average turgor was:

In K solution: roots, 2.2%; stems, 3.6%.
In Na solution: roots, 1.8%; stems, 2.0%.
Excess of K over that in Na solution: roots, 0.4%; stems, 1.6%.

As soon as the material from each culture had been gathered, it was corked tightly in a bottle to prevent egress or ingress of watery vapor, and heated to 120°C. in the autoclave.[18] It was then cooled and all the sap immediately pressed out, filtered, and measured. When the sap did not exceed 20^{cc}, it was all used for analysis. The analysis consisted in oxidizing and removing all organic matter by repeated boiling to dryness with HNO_3 and $HNO_3 + HCl$; filtering and washing residue until no more Cl is dissolved; addition of NH_4OH, which caused no cloudiness; removal of Mg and any other heavy metals by excess of BaOH'; removal of Ba and Ca by precipitation with $(NH_4)_2CO_3$; evaporation to dryness and heating to a white heat; and cooling and weighing. The residue should be entirely soluble KCl and NaCl. For the sake of certainty it

[18] For justification of killing the plants, see deVries, loc. cit.

was refiltered and again dried and weighed. The weight of KCl + NaCl being known, the KCl was removed with $PtCl_4$, the K determined, and the amount of Na found by subtraction.

The statistical results are embodied in the accompanying table, compiled according to Meyer and Seubert's atomic weights.

	Vol. of sap analyzed	KCl + NaCl		KCl		NaCl		K + Na
		Weight	%	%	Equivalence	%	Equivalence	Equivalence
PHASEOLUS:								
K Stem	20^{cc}	0.187^{g}	0.935	0.7078	0.0931	0.2277	0.0391	0.1342
K Root	16	0.0777	0.4856	0.3731	0.0504	0.1125	0.0193	0.0697
Na Stem	12.5	0.0421	0.3368	0.2184	0.0294	0.1184	0.0203	0.0497
Na Root	16	0.072	0.450	0.1038	0.0138	0.3462	0.0593	0.0731
ZEA:								
K Stem	20^{cc}	0.159^{g}	0.795	0.6064	0.0815	0.1785	0.0306	0.1121
K Root	20	0.109	0.545	0.4005	0.0538	0.1445	0.0248	0.0786
Na Stem	10	0.0206	0.206	0.0828	0.0111	0.1232	0.0211	0.0322
Na Root	3.8	0.010	0.263	0.1187	0.0160	0.1445	0.0248	0.0840

The weight per cent. of K and Na was calculated, but is omitted from the table. Comparison with v.Wolff's analyses[19] makes it appear probable that both elements are more abundant in the cell-sap than in the plant as a whole. Still this appearance may be due entirely to different conditions of growth. In the table, K and Na are represented in the form of chlorides merely for the sake of convenience, since analysis yielded them in that form. As both K and Na were present to some extent in all the sap analyzed, the sum of the two is the most suitable character by which to compare the cultures. This sum, of course, should be measured, not by the percentage weight, but by the gram-molecule (the equivalence). Multiplying the figures in the last vertical column by ten will give very nearly the osmotic power of the several mixtures of K and Na salts, measured in per cent. of KNO_3.

The difference in the aggregate of salts of K and Na between the stems of Phaseolus grown in the K- and those in the Na-

[19] Condensed in Ad. Mayer: Ernährung der grünen Gewächse, 307. Heidelberg, 1895.

bearing solutions is sufficient to create a difference in the turgor of 0.85 per cent., while the difference actually observed was only 0.7 per cent. This was exceptional, but in general the variation in the sum of the alkali metals followed that in the turgor quite satisfactorily. Only in the roots of Phaseolus did this fail. In these the per cent. of $KCl+NaCl$ was greater in the K cultures, but the greater proportion of the lighter salt makes the mixture really more concentrated in the Na plants. The excessive turgor of the stems of Zea in the K solution (4%) was too much to explain by the accumulation of potassium. Still their sap contained 3.5 times as much of $KCl+NaCl$ as did that of the Na plants. The stems of both Phaseolus and Zea grown in Na culture were strikingly weak in K+Na, much more effected in this respect than were the roots by the supplanting of the potassium, the plant appearing less able to make its preference felt in the organs in immediate contact with the substratum.

To make this table perfect to the chemist's eye a correction would have to be introduced for the degree of dissociation. It is said that the most completely dissociated of all salts are those of sodium. If this be true, the combined osmotic power varies a very little more widely than does the combined equivalence from the sum of the per cents. of Na and K present in any mixture. Assuming still, however, that K and Na are present as chlorides, the available data point in the opposite direction, for Kohlrausch's[20] original determinations of electrical conductivity and Landolt and Börnstein's compilation, based partly on newer figures from Kohlrausch, both represent the potassium chloride as the more highly dissociated.

From the analysis of the sap we must conclude then that *the influence of potassium on the turgor of the plant is direct.* When offered to the roots it is taken up and stored in the cell-sap, where it becomes an important part of the osmotically active material which keeps the cell and plant turgid. This function it does not share with sodium. Well known as is the useless-

[20] Ueber das Leitungsvermögen einiger electrolyte in aenssserst verdünnter wässriger Lösung. Wied. Ann. **26**: 161 (p. 195).

ness to the plant of sodium as a chemical, this conclusion is still surprising. The phenomenon of turgescence is explicable by purely physical laws, and is dependent on the vitality of the plant only for the semi-permeable membrane, the living protoplasm differentiated as "Hautschicht." And yet, here where the physical properties of sodium would seem to give it a distinct advantage over the heavier potassium, leaving out of consideration the relative scarcity of the latter, we find the plant's insistence on potassium as decided as it is for the vital processes of growth and photosyntax. Indeed, in many instances (Phaseolus, Pisum) the effect of want of potassium appears in the turgor, while growth still continues normal. The plant can exhaust to the last trace the potassium of its substratum, yet it was found in appreciable quantity in the cell-sap of plants whose protoplasm was dying for want of it; as Zea (3a and 3b) after a large part of the plant was brown and dry still showed its highest turgor in the parts still living. Though the living plasma may bound itself toward the cell sap with the same "Plasmahaut"[21] which it opposes on the other side to its environment, yet the vacuole is physiologically as truly a vital part of the cell as is the alimentary canal an essential part of the human being.

The laboratory work whose results are embodied in this paper was performed at the University of Wisconsin in the laboratories of Professor Barnes and Dr. Kahlenberg, to whom I wish to express my sense of obligation for the admirable equipment placed at my disposal, and for their kindly assistance at all times.

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[21] W. Pfeffer: Zur Kenntniss der Plasmahaut und der Vacuolen, etc. Leipzig, 1890.

A LIST OF PLANTS COLLECTED BY THE CORNELL PARTY ON THE PEARY VOYAGE OF 1896.

W. W. ROWLEE and K. M. WIEGAND.

THROUGH the generosity of Mr. E. G. Wyckoff it was arranged that a party of Cornell professors and students representing the geological department of the University should accompany Lieutenant Peary upon his trip to northwest Greenland during the summer of 1896. The party was organized by Professor R. S. Tarr. At first he contemplated inviting a professional botanist to accompany him; but later, largely on account of the additional expense which this course would naturally cause, he decided to abandon this part of the enterprise and depend entirely upon his own assistants for the collection of botanical material. Considering that the main object of the expedition was geological rather than botanical study, the success from a botanical standpoint is surprising. In all about one hundred and thirty-five species and varieties of spermatophytes were collected, and the interesting series of specimens representing Brown's arctic willow (*Salix Grœnlandica*) gives positive testimony of the zeal and success with which the party studied the flora of the places where they stopped.[1] The collection from the Nugsuak peninsula is perhaps the most complete yet secured by an American expedition.

The first collection was made at Turnavik island on the Labrador coast July 20th. Some collections were made at Big island along the northern shore of Hudson strait, and at White strait, Baffin's land, July 25th to 27th. Godhavn upon the island of Disco was visited August 2d and 3d, and finally the main collecting ground of the trip, the Nugsuak peninsula, situated in lat. 74° 15′, was reached August 7th. There in three camping places the party remained until September 7th. Of

[1] Professor Tarr was aided in this work by J. O. Martin, who did by far the greater part of the purely botanical work.

the three camps given in the list of localities Camp 1 was near Wilcox head and near the open sea, Camp 2 was midway between the open sea and the ice front, and Camp 3 was near the ice front. It was from Camp 3 that excursions were made to the Devil's Thumb and to Mt. Schurman.[2] The latter, about seven miles inland from the ice front, is a mountain covered with ice except its summit. From the observations made by the party it seems certain that this mountain top was recently entirely covered by the ice cap. It is interesting on this account to notice the plants that have found their way to the mountain. This is the list:

Savastana alpina
Carex Bigelovii
Juncoides hyperboreum
Papaver alpinum
Cardamine bellidifolia
Potentilla emarginata
Cassiope tetragona
Vaccinium uliginosum microphyllum
Antennaria alpina

These are all perennial plants. In every case but few specimens of each species were seen, although all are abundant along the Greenland coast and for the most part throughout the arctic regions. Antennaria is the only one with appendages upon the fruit for wind dissemination, and Vaccinium alone has fleshy fruits. All have minute seeds. The cliffs of the mountains are favorite nesting places for birds, and no doubt they carry seeds across the ice and leave them upon the mountain. Such as have the hardiness to do so germinate and maintain themselves, all others perish.

PLANTS COLLECTED IN LABRADOR AND BAFFIN'S LAND.

Phippsia algida (Soland.) R. Br. Turnavik; Big island.

Savastana alpina (Sw.) Scribn. Turnavik; Big island.

Trisetum subspicatum (L) Beauv. Big island.

Elymus arenarius L. Cumberland sound.

Carex brunnescens (Pers.) Poir. Turnavik.

Carex glareosa Wahl. Turnavik.

Specimens much larger than those from Greenland.

[2] A map of the region about the Nugsuak peninsula will be found. Bull. Geol. Soc. Am. 8 : 251–268. 1897.

Carex membranopacta Bailey. Big island.

Carex Bigelovii Torrey. Big island.

Carex sp. Turnavik island.

A form differing from *C. Bigelovii* in having comparatively shorter narrower leaves, less sheathing at the base of the stem; rootstocks more slender; staminate spikes commonly two (rarely only one) 8–15^{mm} long, approximate, acute; pistillate commonly solitary (rarely two), 10^{mm} distant from the staminate (10–15^{mm} long), acute; perigynia obovoid, obtuse, granulate, completely covered by the black scale.

Carex rariflora J. E. Smith. Turnavik.

Carex saxatilis L. Turnavik.

Eriophorum vaginatum L. Turnavik.

Eriophorum Scheuchzeri Hoppe. Big island.

Scirpus cæspitosus L. Turnavik.

Juncoides hyperboreum (R. Br.) Sheldon. Big island.

Iris Hookeri Penny. Turnavik.

Salix arctica diplodictya (Traut.) And. Big island.

Mr. Bebb considered the two species of Dr. Trautvetter (*S. diplodictya* and *S. crassijulis*) as confluent. Andersson makes them varieties, and uses Trautvetter's names for them. The characters of our plants certainly correspond to those given in Trautvetter's description of *S. diplodictya*. However, until more evidence can be accumulated it may be well to follow Andersson's conservative arrangement and consider them as varieties. We have not seen Dr. Bell's plant from Cape Prince of Wales, Hudson strait. Lange includes this variety in the *Flora Grœnlandica* and says of it "formas transitorias inter *S. arctica* Pall. et *S. Grœnlandica* (And.) Lundstr." So far as we have seen specimens the species are quite distinct.

Salix Uva-Ursi Pursh. White strait.

Two quite distinct forms were collected: Form *a*, with depressed stems, very short-peduncled aments, and elliptic-obovate very short petioled leaves 5–6^{mm} long by 3–4^{mm} wide, rounded at the apex and distinctly crenate-serrulate. Form *b*, with less depressed stems; peduncles relatively long, bearing three to four scattered leaves smaller than the leaves of the sterile shoots, aments more loosely flowered; leaves spatulate, distinctly petioled, 10–12^{mm} long by 3–5^{mm} wide, very indistinctly serrulate or entire, acute at the apex.

Salix Grœnlandica (And.) Lundstr. Turnavik; Big island; Baffin's land.

Salix herbacea L. Big island.

Salix reticulata L. Big island.

Apparently rare; only the pistillate plants were collected.

Polygonum viviparum L. Turnavik; Big island.

Silene acaulis L. Turnavik; White strait.

Melandrium apetalum (L.) Fzl. Big island.

Alsine longipes (Goldie) Coville. Turnavik.

Cerastium alpinum L. (var. *lanatum* Lindbl.) White strait; Turnavik; Big island.

Ranunculus nivalis L. Big island.

Papaver arcticum L. White strait; Big island.

Draba Fladnizensis Wulf. (*D. Wahlenbergii heterotricha* Lindbl.). Big island.

Draba alpina L. White strait.

Leaves 1^{cm} long, spatulate, densely hirsute with forked hairs; scapes 5^{cm} high; flowers racemose, petals pale yellow, twice the length of the calyx; elliptic pods, calyx and scapes hirsute with forked hairs.

Draba algida Adams. White strait; Big island.

Our plants are quite distinct from *D. alpina;* leaves large, $2–2.5^{cm}$ long, spatulate and very flaccid, nearly glabrous, except some marginal hairs toward the base; scapes scarcely longer than the leaves, finely pubescent with forked hairs; petals twice the length of the calyx, deep yellow; calyx and pods glabrous.

Cochlearia Grœnlandica L. Turnavik.

Cardamine bellidifolia L. White strait.

Sedum roseum (L.) Scop. Turnavik.

Saxifraga cernua L. Big island; Turnavik.

Saxifraga rivularis L. Big island.

Saxifraga cæspitosa L. Big island.

Saxifraga tricuspidata Retz. White strait.

Saxifraga oppositifolia L. White strait.

Rubus arcticus L. Turnavik.

Rubus Chamaemorus L. Turnavik.

Potentilla nana Willd. White strait.

Potentilla tridentata L. Turnavik.

Dryas integrifolia M. Vahl. White strait.

Lathyrus maritimus Aleuticus Greene (White, Bull. Torr. Bot. Club **21**: 430. 1894). Turnavik.

Many arctic and Alaskan specimens usually referred to *L. maritimus* are quite different from the more southern plants. There is some doubt, however, as to whether they should be considered as forming a distinct species. The Alaskan plants have been well described in the above cited article as var. *Aleuticus* Greene. Our material from Labrador agrees in every particular with this description, and is identical with the specimen in the Columbia University Herbarium cited by Mr. White, which we have carefully studied. This variety is characterized by a low and very slender stature; stem and lower surface of the leaves hairy; the latter smaller than in the type (1.5–3^{cm} long), elliptical, acute, and not prominently veined.

Empetrum nigrum L. Turnavik.

Chamaenerium latifolium (L.) Sweet. White strait.

Cornus Suecica L. Turnavik.

Pyrola rotundifolia pumila Hornem. Big island.

Ledum palustre L. Big island; Turnavik.

Ledum Grœnlandicum Œder. Turnavik.

Kalmia glauca Ait. Turnavik.

Phyllodoce cœrulea (L.) G. &. G. Turnavik.

Cassiope tetragona (L.) Don. White strait; Big island.

Cassiope hypnoides (L.) Don. Big island.

Chamæcistus procumbens (L.) Kuntze. Turnavik; Big island.

Vaccinium uliginosum microphyllum Lge. Turnavik; White strait.

Vaccinium Vitis-Idæa L. Turnavik.

Diapensia Lapponica L. Turnavik; Baffin's land.

Menyanthes trifoliata L. Turnavik.

Castilleia pallida septentrionalis Gray. Turnavik.

Pedicularis hirsuta L. White strait; Big island.

Pedicularis lanata (Willd.) Cham. Big island.

Pinguicula vulgaris L. Turnavik.

Plantago maritima L. Turnavik.

Lonicera cœrulea L. Turnavik.

Solidago Virgaurea L. Turnavik.

PLANTS COLLECTED ON THE WEST COAST OF GREENLAND.

Alopecurus alpinus Smith. Camp 3; Wilcox head.

Found mostly where Esquimaux have camped. Probably transported from place to place by them.

Phippsia algida (Soland.) R. Br. Nugsuak peninsula.

Savastana alpina (Sw.) Scribn. Camp 2; Mt. Schurman; Camp 3.

A few isolated spears only were found on Mt. Schurman.

Trisetum subspicatum (L.) Beauv. Disco island.

Poa alpina L. Godhavn, Disco; Camp 3; Wilcox head.

Poa flexuosa Wahl. Godhavn, Disco; Camps 2 and 3; Wilcox head; Devil's Thumb. Quite common on Disco island and at Camp 3.

A large and small form occurs; the taller according to Mr. Martin grows in gull's droppings, especially in shady places. It has been described as

Poa flexuosa elongata Blytt. Nunatak no. 1; Nugsuak peninsula.

Festuca duriuscula L. Godhavn, Disco.

Atropis vilfoidea (And.) Row. & Wieg. n. nom. (*Catabrosa vilfoidea* And. Vet. Akad. Forh. 254. 1862.) (*Glyceria vilfoidea* Th. Fr. Kgl. Vet. Akad. Ofv. 139. 1869.) Wilcox head.

Carex glareosa Wahl. Devil's Thumb.

Carex lagopina Wahl. Godhavn, Disco.

Carex nardina Fries. Nunatak no. 1; Nugsuak peninsula; Disco island.

Carex capitata L. Godhavn, Disco.

Carex Bigelovii Torr. Godhavn, Disco; Camp 2; Mt. Schurman; Devil's Thumb; Nugsuak peninsula.

Carex rigida Good. Camp 3.

Carex stans Drej. Wilcox head.

Carex rariflora J. E. Smith. Found growing in Sphagnum on a hillside on Disco island.

Carex scirpoidea Michx. Nunatak no. 1 and Camp 2 Nugsuak peninsula.

Eriophorum Scheuchzeri Hoppe. Wilcox head; Camp 2; Godhavn, Disco.

Juncus trifidus L. Godhavn, Disco.

Juncoides parviflorum (Ehrh.) Coville (var. *fastigiata* Buch.), Godhavn, Disco.

Juncoides spicatum (L.) Kuntze. Disco island.

Juncoides hyperboreum (R. Br.) Sheldon. Disco island; Camps 2 and 3; Wilcox head; Mt. Schurman; Nunatak no 1.

Juncoides nivale (Laest.) Coville. Camps 2 and 3.

Our specimens are *Luzula arctica* of Lange's *Flora Grœnlandica*, characterized as having leaves long acuminate, and seem to agree with Læstadius' description of *L. campestris* var. *nivalis*, but differ from Buchenau's description of *L. arctica* with leaves obtuse at the apex. They have very slender scape-like stems 12^{cm} high, terminated by a single dark-brown spike, rarely with a second peduncled one; whole plant glabrous; leaves rosulate at the base of the stem, flat and broadly subulate, tapering from the 3^{mm} wide base to the fineness of a hair at the apex, 3^{cm} long.

Tofieldia palustris Huds. Rather common in the sand along the shore on Disco island.

Salix glauca L. Godhavn, Disco.

Some forms of *S. Grœnlandica* closely resemble this species.

Salix Grœnlandica (And.) Lundstr. Godhavn, Disco; Wilcox head; Camps 2 and 3.

Specimens of this species showing the greatest variability were collected at nearly all the stations. Eight forms seem to be represented, some of which are quite distinct. Andersson's varieties *angustifolia* and *latifolia* were both collected.

Salix Grœnlandica leiocarpa (And.) Lundstr. Godhavn, Disco; Wilcox head.

This very distinct form was no. 224 of the Peary Auxiliary Expedition of 1894.

Salix herbacea L. Wilcox head.

Betula nana L. Godhavn, Disco; Camp 2. Mostly on rocky talus.

Oxyria digyna Hill. Wilcox head; Godhavn.

Polygonum viviparum L. Disco; Devil's Thumb; Camps 2 and 3; Wilcox head.

Silene acaulis L. Godhavn, Disco; Camps 2 and 3.

Viscaria alpina Fzl. Disco.

Melandrium triflorum (R. Br.) Vahl. Camp. 2; Wilcox head.

Melandrium involucratum (Ch. & Schl.) Lange. Disco; Nunatak no. 1; Nugsuak peninsula.

Arenaria biflora (L.) Wahl. Godhavn, Disco.

Ammodenia peploides (L.) Rupr. (var. *diffusa* Hornem.). Godhavn, Disco.

Alsine longipes (Goldie) Coville. Disco island.

Cerastium alpinum L. (var. *lanatum* Lindbl.). Godhavn; Devil's Thumb; Camp 3; Wilcox head; Nunatak no. 1.

In clefts of rocks; most luxurious where gulls have nested. It is much matted in its growth like our garden chickweed which it much resembles.

Cerastium trigynum Vill. Disco island.

Ranunculus pygmæus Wahl. Godhavn.

Papaver alpinum L. Godhavn; Mt. Schurman; Camp 3; Devil's Thumb; Wilcox head.

Draba crassifolia Graham. Disco island.

Flowers apparently white.

Draba hirta rupestris Hartm. Godhavn; Nunatak no. 1; Devil's Thumb.

Draba corymbosa R. Br. Godhavn.

Draba corymbosa grandidentata Lge. Godhavn.

Cardamine bellidifolia L. Mt. Schurman.

Cardamine bellidifolia sinuata J. Vahl. Camp 2.

Leaves dentate and flowers larger than in the type.

Arabis alpina L. Godhavn. In rich soil.

Arabis alpina glabrata Hartm. Godhavn.

Saxifraga cernua L. Godhavn; Camp 3; Nunatak no. 1.

Saxifraga rivularis L. Godhavn; Nunatak no. 1.

Saxifraga cæspitosa L. Disco island; Wilcox head.

Saxifraga cæspitosa palmata Hartm. Disco island.

Saxifraga tricuspidata Rottb. Godhavn; Devil's Thumb; Camps 2 and 3; Nunatak no. 1.

Saxifraga comosa (Poir.) Britton. Wilcox head; Camp 3.

Saxifraga nivalis L. Godhavn; Camp. 3.

Saxifraga oppositifolia L. Devil's Thumb. In comparatively well drained soil.

Potentilla rubens Vill. Godhavn.

Potentilla nivea pinnatifida Lehm. Godhavn.

Our specimens seem to be nearer this variety than the type. The plants

are very large (3^{dm}), much branched; flowers cymose (18^{mm} diam.), petals one-half longer than the calyx; leaflets 3 (rarely 4), tomentose beneath, oblong, pinnately cleft, terminal $2.5–3.5^{cm}$ long.

Potentilla Vahliana Lehm. Wilcox head.

Potentilla emarginata Pursh. Camp. 3; Mt. Schurman.

Besides the ordinary form a large form was collected on Nunatak no. 1 with very long and slenderly petioled leaves (15^{mm} long), terminal portion of the leaf pedicelled (pedicel $3–4^{mm}$ long), acutely and very coarsely incised; stems long and runner-like ($15–23^{cm}$).

Sibbaldia procumbens L. Godhavn.

Dryas integrifolia M. Vahl. Godhavn; Camps 2 and 3; Wilcox head.

Alchemilla alpina L. Godhavn.

Empetrum nigrum L. Camps 2 and 3; Devil's Thumb.

Chamænerium angustifolium (L.) Scop. Godhavn.

Chamaenerium latifolium (L.) Sweet. Camp 3; Devil's Thumb.

Chamaenerium latifolium tenuiflorum Fr. Godhavn.

Epilobium alpinum L. Disco island.

Epilobium Hornemanni Reich. Godhavn.

Pyrola rotundifolia pumila Hornem. Camp 3; Devil's Thumb; Godhavn.

Ledum palustre L. (var. *decumbens* Lange). Disco.

Phyllodoce cærulea (L.) G. & G. Godhavn; Camp 2.

In rather dry places.

Cassiope tetragona (L.) Don. Camps 2 and 3; Mt. Schurman; Disco.

The party used this as material for beds while in camp.

Cassiope hypnoides (L.) Don. Disco; Camps 2 and 3.

Chamæcistus procumbens (L.) Kuntze. Camp 2.

Vaccinum uliginosum microphyllum Lge. Camps 2 and 3; Mt. Schurman; Godhavn.

Only a single specimen of this was found on Mt. Schurman.

Rhododendron Lapponicum (L.) Wahl. Ice front, Camp 3.

Diapensia Lapponica L. Camps 2 and 3.

Armeria Sibirica Turcz. Disco.

Pneumaria maritima (L.) Hill. Disco.

Leaves in our plants not glaucous.

Veronica alpina L. Disco island.

Our specimens grade gradually from stout forms with elliptical leaves to slender ones with linear acute leaves.

Bartsia alpina L. Godhavn.

Pedicularis flammea L. Godhavn.

Pedicularis hirsuta L. Godhavn.

Pedicularis Lapponica L. Godhavn.

Campanula rotundifolia Langsdorfiana (A.DC.) Britton. Between Camps 2 and 3.

Upon face of cliffs.

Campanula uniflora L. Godhavn.

Erigeron uniflorus pulchellus Fr. Godhavn.

Antennaria alpina (L.) Gaertn. Disco; Camps 2 and 3; Mt. Schurman.

Arnica alpina (L.) Olin. Disco; Camp 2.

Taraxacum officinale Weber. Godhavn.

Artemisia borealis Pall. Godhavn.

CORNELL UNIVERSITY.

BRIEFER ARTICLES.

DISGUISES IN BUD ARRANGEMENT.

THE law regarding the general arrangement of buds is very simple, but it is not always easy to make all the phenomena of leaf, branch, and flower arrangement agree with the law. This is especially true in the various forms of inflorescence, because in the floral system there is a decidedly greater tendency of potential buds to develop than in the case of the vegetative system; and as flowers can perform their important duty in a somewhat crowded condition as well as when scattered, while leaves must be scattered, the internode is not an important factor in inflorescence as it is in the leaf bearing stem.

One of the simplest disguises of the origin of an inflorescence is seen in various Vitaceæ, Phytolacca, Enslenia, Gonolobus, etc., where each inflorescence terminates the axis, and the succeeding internode is produced by the highest axillary bud. This new internode differs little in size from the preceding, while the stem bearing the inflorescence remains small and is thus thrust aside by the development of the axillary bud. This results in placing the inflorescence opposite a leaf, where it really, but not apparently, terminates the axis. To strengthen this disguise, a small bud is frequently developed in the axil of the leaf opposite the inflorescence, making it appear that the terminal bud has continued the vegetative axis, in which case the inflorescence could have no normally placed bud from which to develop. The nature of this little bud will be considered later.

A still more complete disguise is found in many of the Solanaceæ, where the leaf, which in the above cases stands directly opposite the inflorescence, is carried up by adnation the whole length of an internode from its normal position, leaving the inflorescence apparently branching from an internode instead of a node (*fig. 1*). This also results in an unusual arrangement at the node above, where there are two leaves at one node but not opposite. By tearing a portion of the bark bearing the misplaced leaf down to the level of the inflorescence, both the node bearing the inflorescence and the one above will appear normal.

Physalis goes still farther in this form of disguise, and were one not familiar with a less disguised form, as *Solanum nigrum*, it would be very difficult to determine the normal arrangement of the parts. The internode, which in Solanum separates the inflorescence from the node below, fails to develop in Physalis, thus leaving a flower at a node to which it does not belong and hence neither axillary nor opposite to any leaf at that node. At the same time the leaf which properly opposes the inflorescence is carried upward, as in Solanum, to the level of the next node. If we conceive a node to be formed between the present nodes and the flower raised to it from the node below, and the leaf lowered to it from the node above, the nodes will all be perfectly normal. If the inflorescence of Solanum is split down to the node below, it will be seen to present precisely the arrangement of the Physalis node, and the irregularities may be very easily removed by cutting the flower from one node, and then the leaf to which that flower belongs from the node above, and so on.

FIG. 1. A portion of stem of *Solanum nigrum*, showing position of the inflorescence and of the leaf belonging to the same node.

Dichotomy is another common peculiarity among the Solanaceæ. This is due to the equal development of the primary axis and an axillary branch, and its nature is often obscured by the leaf of the node below being carried, by adnation, to the point where the stem forks, while the leaf to which the lateral branch of the fork is axillary is carried up in a similar manner to the first node of that branch.

The bract of *Tilia Americana* (*fig. 2*) shows how the removal of a bract from its normal position may serve a very useful purpose. This bract is primarily the homologue of a bud scale, or more remotely of a petiole of a leaf. Its midrib is adnate to the peduncle for half the length of the bract, and being persistent with the fruit serves as an efficient means of seed dispersal. There has been some difference of opinion as to the homology of the bract of Tilia, but a careful examination will suggest very forcibly that the bract is a case of adnation

rather than an outgrowth of the peduncle, that it has a foliar rather than a cauline origin. Further proof that this bract is a leaf organ may be found in the buds (represented in cross section in *fig. 2*). Every bud where an inflorescence does not occur has the first bud scale

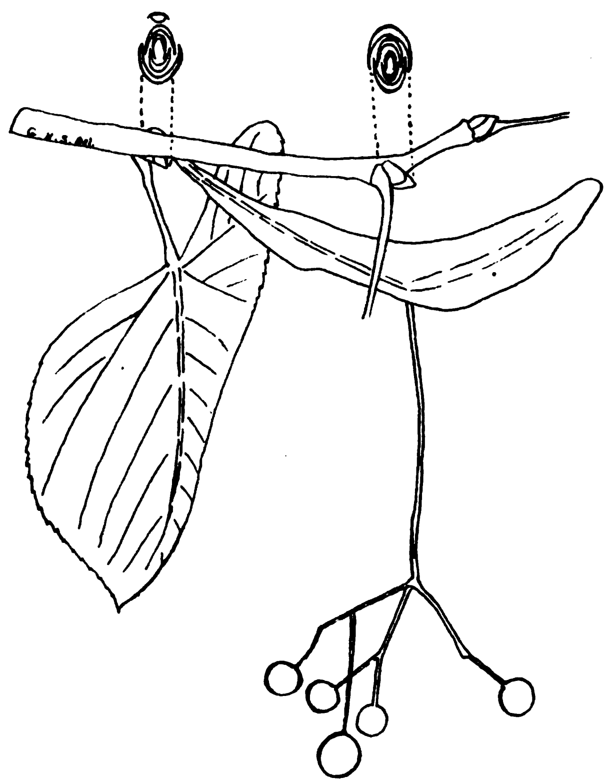

FIG. 2. Infloresence and bract of *Tilia Americana*, with cross section of two buds.

on the upper side. Where an inflorescence appears it always arises from the same position relatively that the first bud scale occupies in other buds, while the bud occurring at the same node with the inflorescence invariably has the first bud scale below.

The removal of a subtending leaf or bract from its normal position is not uncommon. Neither is it always so constant in a species as it seems to be among the Solanaceæ. In a number of species studied the bracts were usually normally placed, but frequently appeared above the node

to which they belonged, or stems were adnate for some distance above the bract, so that the bract appeared to be below the node.

Leaf organs are also frequently absent, but there is always a real or potential bud where the leaf or bract should have been had it been present. Several causes may act to bring about the absence of bracts, but crowding the parts in the bud seems to be the chief cause. The inflorescence of *Sambucus Canadensis* is very interesting in this connection. At the primary division of the inflorescence the five rays are nearly equal, and the four lateral rays are each subtended by a bract which exhibits considerable variation in its position, being frequently above its normal position or below the apparent node. At the secondary, tertiary, etc., divisions of the inflorescence, the parts of the whorl are very unequal, and the larger rays which come in contact with the enveloping leaf organs in the bud, and which thus bear most of the pressure, have the subtending bracts entirely obsolete, while the smaller inner rays from the same nodes, being in the center of the inflorescence, are subjected to less pressure and have minute bracts present.

Without an amendment to the law of bud arrangement a true anomaly occurs in the spikes of *Verbascum Thapsus*. In early development the spike does not appear complex, but in the older spikes or older portions of the spike each bract is seen to subtend a group of buds as shown in *fig. 3*. In the younger portions of the spike the upper bud (1) of the group is the only bud present, and is nestled close in the axil of the bract, hence it is a true axillary bud.. This bud is removed from the axil by subsequent growth and another bud (2) takes its place, and is evidently just as truly an axillary bud as the first. About the time this second axillary bud appears, accessories (3, 3) appear at the base of the primary axillary bud, each being subtended by a bract, as is normal with accessory buds. Further growth also removes the secondary axillary bud from the axil of the bract, and a tertiary axillary bud (5) is developed in the axil, while accessories (4, 4) appear at the base of the second axillary bud. I have chosen to call these primary, secondary, and tertiary buds because they in nowise differ from one another except in the time of their appearance.

In a previous paper[1] it was suggested that the bud which produces an extra-axillary branch in the case of *Juglans cinerea* is really the true axillary bud, because no accessory bud was found which regularly pro-

[1] BOTANICAL GAZETTE, 21 : 168. 1896.

duced a branch except in case the axillary bud was destroyed or produced some other organ. Further investigation shows this to be a case precisely similar to that of Verbascum, and the extra-axillary branch is produced by the primary axillary bud while a secondary bud appears in the axil of the leaf. This also occurs in *Juglans nigra* and species of Carya, though here the primary axillary bud is not so far removed from the axil and the secondary remains quite small. To the same class belong those minute buds which occasionally appear in the axil of a leaf after the primary axillary bud has developed into a branch, as in the above mentioned cases where the terminal bud produces an inflorescence and the vegetative axis is continued by the axillary bud.

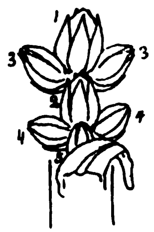

FIG. 3. A group of buds subtended by a single bract in *Verbascum Thapsus*. The numbers indicate the order of development and also of flowering.

There is nothing anomalous about the whorled flower clusters that occur in the axils of the leaves of certain of the Labiatæ, Polygonaceæ, etc., except that the axis of the inflorescence is very much reduced. This is not always plainly evident, but the illustration of *Mentha Canadensis* (*fig. 4*) shows an inflorescence in which this reduction is not complete, and the whole cluster of flowers is plainly seen to be simply a much reduced cyme. Being familiar with such an inflorescence as that of *Mentha Canadensis* it is not difficult to trace the same formation in cases where the reduction is complete and the flowers are sessile. Thus in *Lycopus sinuatus*, for example, the flowers are all sessile, but they may be seen to be divided into two lateral groups with the single flower terminating the central axis.

In Polygonum fascicles of flowers are surrounded at the base by a group of minute scarious bracts, to which the individual flowers are axillary, while in Rumex the flowers are so numerous and so crowded that the bracts are obsolete, but the origin of the flowers is undoubtedly the same as that of the flowers of Polygonum.

The origin and normal arrangement of buds may frequently be inferred from the order of flowering, for anthesis takes place in the order of development. Ordinarily, in a fascicle formed by the reduction of a determinate inflorescence, the flower which blooms first terminates the central axis of the cluster, and the next to bloom will be the terminal buds of the lateral clusters, and so on. In a dense

indeterminate inflorescence the lower or outer buds normally bloom first, because the terminal bud continues vegetative while the axillary buds are forming floral organs. As the order of anthesis and that of development are the same, whatever affects the order of development will in like manner affect the order of flowering. Thus, if for any cause the terminal bud of a normally indeterminate inflorescence develops floral organs before the last lateral buds have attained a like state of development, a mixed inflorescence results, as has been occasionally seen in Digitalis.

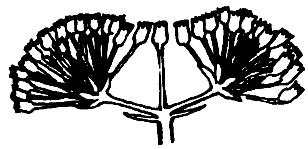

FIG. 4. Verticillate inflorescence of *Mentha Canadensis*.

A very interesting case of variation from the normal order of development is seen in the genus Dipsacus, where the dense crowding of the flowers in the head forces the lower buds down against the involucre and so retards their development. The next circle of buds is not crowded so much, and the development is proportionately less retarded. The pressure becomes less and less as the buds occupy a higher and higher position in the head, until at about the middle a point is reached where the bud pressure is so much reduced that from that point to the apex of the head a normal order of development obtains, showing Dipsacus to have a normally indeterminate inflorescence. In flowering the center of the head blooms first, and thence one flower zone proceeds upward according to the normal order of development, and another downward according to the order of development brought about by bud pressure.

SUMMARY.

1. Most cases of branch and flower arrangement may be explained by the law that a bud, real or potential, occurs in the axil of every leaf, and terminates every axis.

2. If a bud is removed from the axil of a leaf by adnation or by development into a branch, a secondary axillary bud may form in the axil of the leaf, and if that too is removed a tertiary axillary bud may form, etc.

3. Bud pressures explain reduction of bracts and their failure to appear, as well as many modifications in the normal order of anthesis. —GEO. H. SHULL, *Yellow Springs, Ohio.*

NOTES ON FLORIDA PLANTS.

THE collections made the past season by Mr. A. H. Curtiss, for the current fascicle of his valuable series of Florida plants, contain so many species of unusual interest, either as novelties or as exhibiting striking additions to our knowledge of geographical ranges, that the following notes may prove of interest:

RYNCHOSPORA FUSCA Ait. Hort. Kew. (ed. 2) 1: 127.

This northern species, not previously reported south of Delaware, was found by Mr. Curtiss along moist roadsides at Milton, west Florida, July 8, 1897 (no. 5929).

Cyrtopodium ecristatum, n. sp.—Scape slender, erect, 4 to 12^{dm} high, from one or more roundish tubers 2 to 2.5^{cm} in diameter: leaves erect, lanceolate or linear-lanceolate, strongly 3-ribbed, 2 to 5^{dm} long: racemes loosely or closely flowered, 6 to 12^{cm} long, bracts lance-acuminate or linear-attenuate, the lowest 3 to 5^{cm} long, much exceeding the small flowers, the uppermost shorter, about equaling the flowers: sepals and petals oblong, 8 to 10^{mm} long; lip crestless, rather deeply 3-lobed near the base; the middle lobe 5 to 6^{mm} broad, suborbicular, the margin slightly crenulate and infolding; the lateral lobes widely spreading, oblong or obovate-oblong, 4 to 5^{mm} long: column short, 4 to 5^{mm} high: capsule erect, elliptic-ovoid, 2^{cm} long.—*Bletia verecunda* Chapm. Fl. 456, not Swartz. *C. Woodfordii* Chapm. Fl. (ed. 3) 482, not Lindl.

Common in the dry pine lands of eastern Florida, blooming throughout the summer (*fide* Curtiss). Near Jacksonville (type) and borders of Indian river (A. H. Curtiss, no. 2808), Tampa (A. P. Garber), near Eustis, and at Titusville (G. V. Nash, nos. 1571 and 2294). This plant has been generally known in American herbaria as *Bletia verecunda*, from which rose-colored species it is obviously very distinct. In 1881, in a letter to Dr. Watson, Bentham pointed out that the plant was a Cyrtopodium related to the West Indian *C. Woodfordii*. From that species it differs markedly in size, *C. Woodfordii* being a comparatively stout plant. The flowers of *C. ecristatum*, too, are much smaller, the lateral lobes of the lips more spreading, and the column much shorter than in *C. Woodfordii*; and the middle lobe of the lip, which in *C. Woodfordii* is sparingly crested, in *C. ecristatum* is quite naked. According to Mr. Curtiss, the flowers of the Florida plants are yellowish outside and purplish brown within.

ALTERNANTHERA PUNGENS HBK. Nov. Gen. et Sp. **2**: 206.

This South American and Mexican species, which has formerly been reported from Mobile,[1] has recently been found by Mr. Curtiss introduced about the streets of Pensacola (no. 5921).

JUSSIÆA SUFFRUTICOSA L. Sp. Pl. 388.

The first record of this plant in the United States was Dr. Small's recent note of Dr. Mohr's station at Mobile, Ala.[2] Mr. Curtiss found the plant in low ground at Pensacola, July 2, 1897 (no. 5918).

HYDROCOTYLE BONARIENSIS Lam. Encyc. **3**: 153.

This interesting tropical species, which has recently been reported by Mr. Pollard from Mississippi,[3] was collected by Mr. Curtiss in low grassy ground at Pensacola, July 3, 1897 (no. 5922), thus making known a second station for the plant in the United States.

SOLANUM ELÆAGNIFOLIUM Cav. Ic. **3**: 22. *pl. 243*.

This species, common in the southwestern states, has been found by Mr. Curtiss in ballast and along streets at Pensacola (no. 5913).

CHRYSOPSIS GRAMINIFOLIA Ell. var. **latifolia**, n. var.—Stouter than the type; the stems densely leafy: the silvery leaves broadly oblanceolate or oblong-lanceolate, strongly 5 to 7-nerved; the lower cauline 10 to 15^{cm} long, 2 to 3^{cm} wide, blunt or rounded at the tips; the upper shorter, with less rounded or acute tips: inflorescence less diffuse and of fewer heads than in the type; the bracteiform leaves linear-lanceolate, 2 to 3^{cm} long: heads as in the type, but the fusiform akenes longer, 4^{mm} long, and the pappus shorter, 6^{mm} long.

Collected in "spruce pine" land, Jensen, March 25, 1897, by A. H. Curtiss (no. 5819); and in 1874 in east Florida (no station given) by Dr. Edward Palmer (no. 259). A plant habitally well distinguished from *C. graminifolia*, but passing by various gradations to it. The akene and pappus characters, which on the whole are good, are not strictly to be relied upon. In typical *C. graminifolia* the akenes average 2.5 to 3^{mm} in length, but in large specimens they are fully 4^{mm} long, thus equaling those of var. *latifolia*. The pappus, too, of *C. graminifolia* is inconstant in its length. In most specimens it is 8 or 9^{mm} long, but specimens of good *C. graminifolia* are found with the pappus only 6^{mm} long. The var. *latifolia* is well distinguished habitally from the species by its approximate broad and obtuse leaves, which in the inflorescence become merely linear-lanceolate, not linear-subulate, as in the

[1] ULINE and BRAY, BOT. GAZ. **20**: 450.

[2] Bull. Torr. Bot. Club **23**: 129.

[3] Bull. Torr. Bot. Club **24**: 155.

species. But this habital character is shown not to be constant by Mr. Nash's no. 2313, which is exactly intermediate between *C. graminifolia* and the var. *latifolia*. Mr. Nash's plant has approximate acute leaves smaller than in var. *latifolia*, but at the same time much broader than in the true *C. graminifolia*. The akene of Mr. Nash's plant is like that of *C. graminifolia*, while the pappus is short as in var. *latifolia*.

SPILANTHES STOLONIFERA DC. Prodr. 5:621.

This plant, previously known only from Brazil, Paraguay, and Uruguay, was found by Mr. Curtiss in low ground at Carrabelle, near Apalachicola, in June 1897 (no. 5882). The species is distinguished from *S. repens* by its lanceolate or linear-lanceolate, entire or remotely dentate, sessile or obscurely short-petiolate leaves.

MARSHALLIA ANGUSTIFOLIA Pursh, var. CYANANTHERA Ell. Sk. 2:317.

Mr. Curtiss has recently found this well marked variety with Sarracenia, Tofieldia, etc., on seepy slopes of the pine barrens in Walton county, west Florida (no. 5932). The plant is distinguished from the handsome *M. angustifolia* by its slender simple stem, smaller, less conspicuous (Mr. Curtiss says "actually insignificant") heads, and by the short-acuminate involucrate bracts which are lanceolate or oblanceolate and much shorter than the linear-attenuate bracts of *M. angustifolia*. Mr. Curtiss has formerly collected the same form in the pine barrens of Liberty county.

ANTHEMIS MIXTA L. Sp. Pl. 894.

This common Mediterranean species was collected by Mr. Curtiss in 1886 on ballast at Pensacola. It has recently been sent by him from the same station (no. 5914), where it is apparently well established.

HIERACIUM MARIANUM Willd. var. SPATHULATUM Gray, Syn. Fl. 1^2: 455 (Suppl.).

Several Florida specimens distributed as *H. Gronovii* are identical with authentic Pennsylvanian specimens (collected by Traill Greene and Porter) of *H. Marianum* var. *spathulatum*. Mr. Nash's *H. megacephalon*,[4] though a little more leafy, seems to be the same. As a variety of *H. Marianum* the plant seems tolerably well marked, but intermediate forms occur, notably a plant from Asheville, N. C., 1893 (B. L. Robinson, no. 26), which has the essentially radical and densely pubescent leaves of the variety, but the elongated paniculate inflorescence and somewhat smaller head of the species; and a leafy-stemmed plant from Garrett county, Maryland (John Donnell Smith), with the lower leaves pubescent as in var. *spathulatum*.

[4] Bull. Torr. Bot. Club 22: 152.

In distinguishing his *H. megacephalon* from *H. Gronovii* Mr. Nash emphasizes as a specific character of the former its early flowering season, March to May. As represented in the Gray Herbarium, the Florida specimens have been collected as early; but the Pennsylvanian specimens of *H. Marianum* var. *spathulatum*, which seem identical with the Florida plant, were collected early in July, and in the vicinity of Boston the typical *H. Marianum* often flowers by the middle of June. Furthermore, the Gray Herbarium sheet of Simpson's no. 575 (distributed as *H. Gronovii*) from Fort Myers, Fla., May 3, 1892, contains two plants, one of them *H. Marianum* var. *spathulatum*, the other somewhat intermediate between that and typical *H. Marianum*, but much nearer the latter. It would therefore seem that, though the var. *spathulatum* is a spring or early summer form, it is not entirely unique in its flowering season. The following Florida specimens of *H. Marianum* var. *spathulatum* have been examined: Fort Myers (J. H. Simpson, no. 575 in part), Lake City (F. C. Straub, no. 37), Port Orange (F. Straub, no. 86), Eau Gallie (A. H. Curtiss, no. 5818).

M. L. FERNALD, *Gray Herbarium, Cambridge, Mass.*

VIBURNUM DEMETRIONIS.

SINCE publishing *Viburnum Demetrionis* in the BOTANICAL GAZETTE (**22**: 166–7. 1896) we have secured ripe fruit from Mr. C. H. Demetrio, collected by his friend, Rev. E. Heck, at the type locality in central Missouri, August 30, 1896. This material furnishes the following supplementary characters:

Fruit somewhat fleshy, oblong in outline, rounded at the ends, 5 to 6 lines long, 3 lines broad, slightly compressed, shining, black; putamen oblong, strongly compressed, somewhat thicker and slightly pointed at one end; one surface with a median and two shallow intra-marginal grooves, the other with two (often indistinct) intra-marginal grooves; seeds thin, slightly concavo-convex.—W. DEANE and B. L. ROBINSON, *Cambridge, Mass.*

CURRENT LITERATURE.

BOOK REVIEWS.

Injury to plants by cold.[1]

THE prominent and peculiar feature of this research lies in the direct observation, by the use of the microscope, of the phenomena of freezing. A specially constructed box, with triple walls for the non-conduction of heat and for receiving a freezing mixture, enabled the author to enclose his microscope where objects were frozen during observation. On freezing colloids, emulsions and solutions, Molisch found, as others had found before him, that water, on becoming ice, separated itself from the contained material; but Molisch's microscope showed that the colloids formed a network of denser material, the emulsions formed a network of granules, and the solutions formed a network of concentrated or solid substance. Each of these networks contained ice-masses in the meshes. On thawing, the network disappeared *quickly in some of the liquids, but only slowly in others* such as starch paste, which is permanently altered by the freezing.

The author next experimented with the freezing of living bodies, using amœbæ, hyphæ of *Phycomyces nitens*, yeast, Spirogyra, and other algæ, hairs of Tradescantia, and the guard cells of stomata. The results obtained here are directly comparable with those obtained with merely physical bodies. The protoplasm on freezing became a network of denser material, with lumps of ice in the meshes. The capillary filaments of Spirogyra and Phycomyces gave up much of their water to the formation of an external ice mantle, and ice formed internally only at a temperature many degrees below zero, this being comparable with the well-known fact that ice forms in purely physical capillary tubes only when the temperature is several degrees below zero. The guard-cells of stomata were found to form ice only when considerably below zero; and this phenomenon the author explains by the greater content of dissolved substance in these cells, and by their capillarity.

In the next section of this monograph, Molisch seeks to answer the question as to whether plants die from freezing or thawing. Like Göppert, Sachs and Müller-Thurgau, he has tested hundreds of plants by the slow and by the rapid process of thawing, and like all but Sachs he finds, with the excep-

[1] MOLISCH, HANS.—Untersuchungen über das Erfrieren der Pflanzen. Gustav Fischer, Jena, 1897.

tion of one plant, that the slow thawing does not restore to activity. The sole exception was that of excised leaves of *Agave Americana*. If these were frozen in a not too low temperature, slow thawing restored more cells to activity than did rapid thawing. Göppert's work in using the change in color in the indican-holding blossoms of orchids as a test for the death of the protoplasm, was imitated by Molisch in using three marine Florideæ, Nitophyllum, Gelidium and Plocamium, red algæ which become orange on dying. In this test the orange color always came when the plants froze. The author had previously found that the plant *Ageratum Mexicanum* exhaled the odor of cumarin on dying. He therefore used this plant also as a test, and found the cumarin odor appearing when the plant froze. To the reviewer this work on the Florideæ and Ageratum seems the most important part of the whole paper.

The injury to plants by temperature just above 0° was also studied. Molisch concludes, as others have before him, that in many cases the injury is due to excess of transpiration over absorption of water. In other cases the injury cannot be due to this cause, for it takes place when transpiration is checked by external means. Molisch believes that the injury in such cases is due to a disturbance of the metabolism of the organism, and suggests that there may result the accumulation of some toxic product, or a failure in the production of some necessary substance. Many plants, all from warm climates, were used in obtaining this result. A plant especially sensitive was *Episcia bicolor*, whose leaves became brown and contained mostly dead cells after an exposure of four days to a temperature of 3°. Preventing transpiration, shielding from the light, very gradually changing from a warm to a cold temperature, made no difference. Nearly all the species of plants used died within thirty-five days; a few lived two and one-half months; while two plants of *Philodendron pertusum* lived through the winter in the cold, but suddenly died in the first warm days in March.

Lastly, Molisch comes to the theory of death by freezing. Death comes with freezing, not with thawing, and is due to the withdrawal of water from the protoplasm. Thus Molisch finds himself in complete accord with Müller-Thurgau, who has given us a like explanation. The reviewer is not disposed to object to this conclusion in a general way, but would suggest that there are various phenomena, some of which are mentioned in the present paper, that do not come into harmony with the theory. To mention one of these is enough: Müller-Thurgau has found, and Molisch accepts the result, that the more the temperature is lowered, the more is the ice formed, and consequently the more is the water withdrawn from the protoplasm. Molisch states that wilted plants are less likely to be injured by frost than not wilted. This query, of course, comes: Why, according to the theory of injury by freezing, should not a given low temperature leave as much water in the protoplasm of a turgid plant as in that of a wilted plant?—F. C. NEWCOMBE.

Lectures on Bacteria.[2]

The multiplication of text books of bacteriology written from the standpoint of pure science rather than from that of medicine or technical industry is a hopeful sign. It means, let us trust, the ultimate correction of the asymmetrical development of the subject observable in the last few years, and may perhaps presage a certain reaction from the feverish search after all manner of "curative sera." In fact, continued advance along practical lines is possible only if the broader field is sedulously cultivated. The significance to agriculture, for example, of Winogradsky's work upon the nitrifying organism cannot perhaps be overestimated, but it is increasingly apparent that more research into the purely scientific aspects of nitrification must be forthcoming before we can hope to apply practically the results already obtained. The rescue of the subject of bacteriology from too exclusive devotion to test tube and guinea pig, and the return to the more wholesome if less sensational biological methods, will be forwarded by books like these "lectures" of Fischer.

The lectures contain a full disquisition upon the morphology and systematic position of bacteria, the structure of the cell being viewed, so to speak, from the standpoint of a plasmolysist. Bütschli's conception of the "central body" is, of course, stoutly opposed. Nearly one-third of the book is wisely given up to a description of the part played by bacteria in the transformation of nitrogen and carbon compounds; and the fundamental questions of putrefaction, nitrification, nitrogen-assimilation, fermentation, etc., are lucidly, if somewhat didactically, treated. Thirty pages (out of 160) are given to a consideration of bacteria in the rôle of excitants of disease, but in this brief space the author endeavors to set forth the true inwardness of serum therapy, devotes a word and a picture to the phagocyte theory, and has a paragraph even for the new tuberculin preparations "TO" and "TR!" A series of 164 notes at the end of the book, with references to pages of the text, contains some very useful bibliographical material, and serves to bring the lectures quite abreast of our knowledge. Fischer finds himself wholly unable to accept the remarkable observations of Stutzer and Hartleb[3] on the nitrifying organisms (note 72), and completely rejects the notion of extreme polymorphism advanced by these authors, whose investigations he characterizes as "full of gaps and entirely inadequate."— E. O. J.

MINOR NOTICES.

In Merck's Report for August 15 and September 1, Mr. Frederick LeRoy Sargent has a paper on the Rununculaceæ, giving a general account of the morphology of the family.— C. R. B.

[2] Fischer, Dr. Alfred.— Vorlesungen über Bakterien. 8vo. pp. 186. Jena: Gustav Fischer, 1897. *M* 4.

[3] Centrabl. f. Bakt. 3^2: 1897.

A REVISION of the North American Lemnaceæ has been published by Mr. Charles Henry Thompson.[4] It seems that this is the first revision of the North American species, and is based upon a study of the rich Engelmann collection, with Dr. Engelmann's notes and sketches, together with material from the most important collections of the country. The study of herbarium material was supplemented by an examination of abundant living material of nearly every species. The group is difficult on account of its polymorphism, showing two or three distinct phases. The vegetative and reproductive phases result in different looking plants, and the "resting phase," when it occurs, is different from both. Naturally these various phases have brought confusion into descriptions. Spirodela is represented by its single well known species, Lemna contains six, Wolffiella three, and Wolffia three, one of which is new. The contribution is a very valuable bringing together of material.—J. M. C.

A BRIEF ACCOUNT of the life and work of the late Fredrick Wilhelm Klatt is given in the *Bulletin l'Herbier Boissier*,[5] by Dr. Hans Schinz. He was born in Hamburg, February 13, 1825, and died March 3, 1897. He was best known to American botanists by his studies of the Compositae of the American tropics. The bibliography prepared by Dr. Schinz contains forty-nine titles, extending from 1856 to 1896.—J. M. C.

THE SERIES of papers upon "North American Coniferae," published by Dr. Edson S. Bastin and Mr. Henry Trimble in the *American Journal of Pharmacy*, from January 1896 to July 1897, have been brought together in a convenient pamphlet form.—J. M. C.

PARTS 155 to 158, and 161 to 163 of *Die Natürlichen Pflanzenfamilien* are supplements to the second, third, and fourth volumes. Much interesting new material is brought together, and many of the families are brought up to current knowledge. It is interesting to note that the recent discovery of spermatozoids in Cycas and Ginkgo (their discovery in Zamia being too recent to be included) has led to a modification of the characters assigned to gymnosperms, and has induced Dr. Engler to separate the genus Ginkgo from the conifers and make it the type of a distinct family, the Ginkgoaceæ, to which five or six fossil genera also belong. It is strange that this has not been done long ago, even before the spermatozoid discovery. The gymnosperms are further recast by recognizing six great groups ("classes" of Engler) instead of the usual four. We have been accustomed to cycads, cordaites, conifers, and gnetums; but the Engler classes now are Cycadales, Bennettitales, Cordiatales, Ginkgoales, Coniferae, and Gnetales. The numerous further changes in the grouping of

[4] Separate from the ninth annual Report of the Missouri Botanical Garden, pp. 22, *pl. 4*. 1 N. 1897.

[5] 5: 836–839. 1897.

the gymnosperms cannot be noted; but it is with some regret that we abandon the famous name *Welwitschia mirabilis* for *Tumboa Bainesii*. An interesting addition is also made to the literature of the morphology of angiosperms in presenting and illustrating the results of Guignard's work on *Lilium Martagon*. Parts 159 and 160 contain Sphaeriales and Laboulbeniineæ by G. Lindau, and Hemibasidii (Ustilagineæ and Tilletiineæ) and Uredinales by P. Dietel.— J. M. C.

A RECENT CONTRIBUTION from the Gray Herbarium contains the results of Mr. Fernald's recent studies.[6] The first part presents a systematic study of the United States and Mexican species of Pectis. A full historical sketch of the various groupings of the species precedes the synoptical presentation. Thirty-eight species are recognized, and are grouped under five subgenera, Eupectis, Pectidopsis, Pectothrix, Heteropectis, and Pectidium. Six new species are described. The second part contains descriptions of rare and undescribed species collected by Dr. Edward Palmer at Acapulco, Mexico.— J. M. C.

TEACHER'S LEAFLETS, no. 8,[7] is intended to give teachers a knowledge of the minute points of difference in leaves and acorns of the white, bur, chestnut, swamp white, red, scarlet, and black oaks. It is written by Mr. A. P. Wyman and contains illustrations of the leaves and acorns of each kind described. These leaflets must be of great value to teachers who are expected to conduct nature study in primary schools.— C. R. B.

A BOOK of laboratory directions intended primarily to accompany Sedgwick and Wilson's *General Biology* has been prepared by Dr. Harriet Randolph[8] of Bryn Mawr College. This provides specific directions for laboratory work, occupying about six hours a week for the collegiate year. The forms treated are fern, earthworm, amoeba, white blood-corpuscle, lichen, mushroom, bacteria, spirogyra, hydra, mussel, lobster, moss, frog, fish, pigeon, and rabbit. There are also laboratory directions for the study of the stem, bud, leaf, and seed of plants and the circulation of protoplasm, and for the embryology of the frog and chick. The directions are well arranged but seem to us too brief and likely to induce superficiality, especially in view of the short time allotted to each organism. The fern (Pteris) cannot be studied properly in ten hours, the moss (Polytrichum) in five and Penicillium, a lichen and a mushroom in four, unless the students are vastly more expert than most beginners.— C. R. B.

[6] FERNALD, M. L.—Contributions from the Gray Herbarium of Harvard University. From Proc. Amer. Acad. 33: 57–94. 1897.

[7] Teachers Leaflets on nature study: prepared by the College of Agriculture, Cornell University. Address Chief Clerk, as above, Ithaca, N. Y.

[8] RANDOLPH, HARRIET.—Laboratory directions in general biology. 12 mo. pp. vi + 163. New York: Henry Holt & Co. 1897. 80 cents.

THE PREVALENCE of tubercle bacilli in market butter has been made the subject of especial investigation of late by a number of workers. Groening[9] and Obermüller,[10] working independently, have found that a large percentage of samples of butter are able to produce in guinea pigs pathological lesions that were similar to tuberculosis. Smear preparations made from the diseased tissues showed the presence of bacilli that reacted toward stains in a manner similar to the tubercle organism. Groening found in eight out of seventeen cases, bacilli that he identified as tubercle bacilli, although in this determination he omitted to make cultures and critically study the isolated organism. Obermüller's results were even more startling, for in every sample examined (fourteen in number) tubercle bacilli were found.

Lydia Rabinowitsch[11] has recently made a thorough examination of a large number of samples (thirty in Berlin and fifty in Philadelphia) and her results throw grave doubts on the previous results mentioned. She finds in a considerable number of samples (28 per cent.) an organism able to produce in guinea pigs lesions which resemble, microscopically as well as macroscopically, the genuine tubercle bacillus so closely that the two can only be differentiated by the aid of cultures. Furthermore, in not a single case were tubercle bacilli found which agreed in all particulars with the type descriptions. The organism that so closely resembles the true tubercle germ is mildly pathogenic for guinea pigs but not for other animals. Culturally, and in its reaction toward tuberculin, it is readily distinguished from *Bacillus tuberculosis*.

These careful investigations render it extremely probable that the results of other investigators have been misinterpreted owing to the lack of more thorough study of the supposed tubercle organism.— H. L. RUSSELL.

THE PROCEEDINGS of the Indiana Academy of Science for 1896, just issued, bear evidence of a marked botanical activity in that state. Twelve papers upon botanical subjects are published in full, while nearly as many more appear by title only. As might be expected from the organization of a State Biological Survey by the Academy a few years ago, many of the papers are in the nature of contributions to the flora of the state. Those treating of the spermatophytic flora are Messrs. Stanley, Coulter, Hessler, Blatchley, and Chipman. The interesting fact concerning these papers is that they indicate in a marked degree the passing of the day of mere lists of names, and the beginning of local studies of plants in relation to their surroundings. The paper of Dr. Robert Hessler upon the "Flora of Lake Cicott and Lake Maxinkuckee," and that of Mr. W. W. Chipman upon the "Flora of the lake region of northeastern Indiana," in their presentation of the physiographic conditions of the areas studied, in their indications of

[9] Groening, Cent. f. Vet. Viehmarkt. u. Schlachthoflangeleg, 1897, nos. 14–15.

[10] Obermüller, Hyg. Rund. 1897, no. 14.

[11] Rabinowitsch, Zeit. f. Hyg. 26: 90. 1897.

physiographic changes consequent upon the reclamation of swamp lands, and in their notes upon the plant movements necessitated by these changes, bring together a mass of facts of extreme interest and value. Mr. Blatchley, under the title of some "Phanerogams new or rare to the state," records the stations and habitats of ninety-three species, of which thirty-three have not heretofore been recorded as occurring within the state, the remainder being recorded from a single station only. In "Contributions to the flora of Indiana, No. IV," Professor Stanley Coulter discusses "The Compositæ of the state with special reference to their distribution." Of the two hundred and thirteen specimens recorded, it is shown that thirty-six species are reported from a single station; that eight species are strictly northern, twenty-four southern, and one western in distribution within the state; and that the remaining one hundred and forty-four species are of general distribution. Preceding the discussion of the distribution of the species there is given a brief summary of certain experiments touching the germination of Compositæ and the power of resistance shown by seedlings to temperature and moisture changes. These experiments promise to yield results of exceptional importance, and are of more than passing interest.

Additions to the cryptogamic flora of the state are made by Dr. L. M. Underwood and Dr. J. C. Arthur. Miss Lilian Snyder contributes an article upon "The Uredineæ of Tippecanoe county," noting seventy species, fifteen of which have here their first record for the state.

In physiological botany Professor M. B. Thomas discusses "Periodicity of root pressure," arriving at the following general conclusions: the periodicity of root pressure seems to be inherent in the plant, and has either been acquired by previous adaptation to environment, or is the result of the action of some constant or periodic changes in the plant; root pressure does not seem to have any relation to the previous periodicities of the vital activities of the plant when the top was connected with the roots; the measure of the root pressure seems to be the osmotic activity of the root hairs, and is probably due to the presence of organic acids and other substances in the rhizoids that show great affinity for water; although the organic acids increase in the cells at 50°–60° F., their increase does not seem to make any appreciable difference in the periodicity, this being true even when the temperature of the soil is brought up to 55° F., approaching the time of minimum pressure.

Katherine E. Golden records a series of experiments undertaken to determine whether or not the common yeasts have pathogenic properties. Rabbits and guinea pigs were used in the work, the results indicating that yeasts when taken into the stomach of those animals cause neither discomfort, nor lesions in any organ, even when a fermentable substance be eaten at the same time. Injections from wort cultures of yeast were also made in the case of both animals, to note the effect of yeast when introduced into the circulation, but in no case could ill effects be observed. The results of the

experiments agree in the main with those of Neumayer except that he claims that an injury to an animal may always be expected if fermentable substances be taken at the same time as the yeasts.

Professor A. W. Bitting and Charles E. Davis, as the result of a study of "The bacteriological flora of the air in stables," give descriptions and illustrations of eighteen forms studied in detail.

"A revision of the species of the genus Plantago occurring within the United States," by Alida M. Cunningham, suggests an arrangement of species based upon seed characters, in the belief that such characters are most likely to be constant and of diagnostic value. According to Miss Cunningham, the genus may be broken up into three sections, clearly separated by seed characters as follows:

(1) Seeds oval in cross section (*P. cordata, Major, Rugelii, eriopoda, decipiens, maritima, Tweedyi*); (2) seeds more or less anther shaped in cross section (*P. lanceolata, Patagonica, hirtella, Virginica, rubra, minima?*); (3) seeds irregularly lobed in cross section (*P. elongata, heterophylla, Bigelovii*). Miss Cunningham considers that no good reason exists why vars. *aristata* and *gnaphalioides* of *P. Patagonica*, and var. *longifolio* of *P. Virginica* should be raised to specific rank, concluding from seed characters that they should still be considered as varieties. *P. decipiens*, however, she believes, should not be included under *P. maritima*, being clearly separable from that species. So far as examined, all forms labeled *P. major*, var. *Asiatica*, are referable to either *P. major* or *P. Rugelii*. Two new species, *P. rubra* and *P. minima*, are described; *P. rubra* being separated from *P. Virginica* by the dense hairs, acute sepals, shape and dehiscence of capsule, color, cross section and size of seeds; *P. minima* being closely allied to *P. Patagonica*, var. *gnaphalioides*, and separated from it by size, surface of sepals, size of capsule, color, size and surface of seed. The material examined by Miss Cunningham embraced the collections of the National Herbarium, the Herbarium of the University of Minnesota, the Herbarium of Professor John M. Coulter, and that of Purdue University. The work has been done with extreme care, and the analytic keys and figures accompanying the article add greatly to its value.

Miss Clara Cunningham, in a concisely written paper accompanied by two plates, gives the result of experimental studies concerning the "Effects of drought upon certain plants." The result of the experiments served to show that immature plants, subjected to drought even for a very short time, undergo decided changes, not merely in general appearance, but also in structural details.

The volume of proceedings itself is fairly good, so far as the letter press goes, but the proof reading is inexcusably careless in parts, while the plates in the main are admirable illustrations of how plates should not be printed. The work of the Academy is excellent, that of the state printer is not beyond reproach.

NOTES FOR STUDENTS.

ITEMS of taxonomic interest are as follows: Illustrations of *Hypericum galioides*[12] and *H. lobocarpum*[13] have appeared in recent numbers of *Garden and Forest.* W. W. Ashe[14] has prepared a synoptical presentation of the genus Asarum in eastern America, recognizing eight species, four of which are described as new. E. L. Greene[15] has published a fascicle of new species of Trifolium, seventeen in number, also five new species of Streptanthus has segregated two new species from the Apocynum forms of the eastern United States, has described five new species of Eriogonum, has recognized the "hop trefoils" as a good genus bearing the name *Chrysapsis* Desvaux (1827), substitutes *Anthanotis* Raf. for *Podostigma* Ell., and says that *Arafallus* Necker should be used for *Oxytropis* DC. rather than *Spiesia* Necker. A. A. Heller[16] substitutes the generic name Edwinia forthe well known *Jamesia* T. & G. (1840), since Rafinesque has used the latter name in 1832, an unfortunate change which he tries to moderate as much as possible by using the given name of Mr. James. E. Koehne[17] has published further studies of Lythraceæ, among which are included many tropical American forms. C. V. Piper[18] has described a new Rubus from the cañons of Washington, naming it *R. Hesperius.*[19] Carl Purdy has described two new species of Lilium from California and Washington. J. K. Small[20] has described a new oak, *Quercus geminata*, from Florida, also two new species of Celtis, one from Georgia, *C. Georgiana*, the other from Texas, *C. Helleri*, and has published a revision of the species of Gaylussacia in the southern states, recognizing seven species.—J. M. C.

ALBERT KATTEIN, after a study of the development of the vascular bundles of roots and stems, agrees with Van Tieghem and others that the central cylinder of the root is homologous with the bundle complex of the stem rather than with a single bundle, as held by Russow and DeBary. It follows that the pith of the central cylinder when present is homologous with that of the stem in dicotyledons.[21]—C. R. B.

ONE OF THE most interesting papers that has recently appeared is a consideration by Stahl of the cause of nyctitropic and related movements.[22] The author believes that the common view advanced by Darwin, that the movements are to prevent the radiation of heat, can scarcely be the chief cause.

[12] Garden and Forest **10**: 433. 1897. [13] *Ibid.* 453.

[14] Botanical contributions from my herbarium **1**: 1–4. 1897.

[15] Pittonia **3**: 199–230. 1897.

[16] Bull. Tor. Bot. Club **24**: 477. 1897. [19] *Ibid.* 103–105.

[17] Engl. bot. Jahrb. **23**: 17–36. 1897. [20] Bull. Torr. Bot. Club **24**: 438–445. 1897.

[18] Erythea **5**: 103. 1893. [21] Bot. Centralbl. **72**: 55. 1897.

[22] Ueber den Pflanzenschlaf und verwandte Erscheinungen. Bot. Zeit. **55**[1]: 71–109. 1897.

Stahl regards nyctitropic and other related leaf movements to be most intimately connected with the process of transpiration or, in other words, the conduction of solutions from the soil. This view is supported by a large number of facts that are admirably brought into harmonious relationship with each other. True nyctitropic movements are believed to facilitate nocturnal transpiration; in accordance with this view Stahl finds that the stomata of these plants are open at night, and that the leaves, on account of their vertical position, are much less strongly bedewed than are ordinary horizontal leaves.

The absence of dew, of course, facilitates transpiration, and the loss of water is still further favored by the fact that the leaf surface most fully provided with stomata is best concealed from the dew.

Some of the tropical plants, especially legumes, assume the vertical or profile position in strong sunlight. In such cases the movements are undoubtedly to reduce the transpiration, since the danger here is from too great, not too little loss of water. The autonomous movements of *Desmodium gyrans*, which have been hitherto unexplained, are thought to be for the purpose of promoting transpiration, since the movements cause the saturated air to be driven off, thus allowing dry air to come in contact with the transpiring surface. The quaking aspen and other poplars may secure the same results by means of the passive movements of their leaves.

Stahl thus associates all variation in leaf movements in one way or another with transpiration, and the predominantly tropical distribution of plants that show such movements is a strong point in favor of this view. It is a striking fact that the Leguminosæ furnish the larger proportion of plants, and Stahl hints that as they have worked out such delicate apparatus to regulate the transpiration, a condition resulting, perhaps, in a more uncertain food supply, so the strange rhizobium symbiosis, characteristic of the family, may have been assumed to supply the deficit of nitrogen.—H. C. C.

KOHL HAS BEEN carrying on studies in order to ascertain the photosyntactic energy of light of various colors.[23] Engelmann's observations showed that the energy of absorption is a mark of the energy of photosyntax. Kohl accepts these results and conducts experiments on algæ placed in darkened chambers covered with colored glasses. He finds that red light permits about 50 per cent. of the photosyntax of white light, blue light nearly as much green light about 25 per cent., yellow light 12 per cent., and violet still less. The results from blue light are surprisingly large, and are hard to interpret in connection with Sachs' well-known experiments.—H. C. C.

DR. A. J. EWART'S paper[24] on the evolution of oxygen from colored bacteria details some interesting results. He finds that a considerable number

[23] Ber. der deutsch. bot. Ges. 15: 361–366. 1897.

[24] Jour. Linnean Society 33: 123.

of the chromogenic bacteria have the power of evolving oxygen. This is demonstrated in the following manner: A small quantity of the chromogene to be tested is placed on a cover glass, and to this is added a drop of fluid but cool gelatin. When solidified a drop of water containing actively motile aerobic organisms is also added, and the whole at once covered. If certain chromogenic bacteria are used, the motile forms in close proximity to the gelatin will continue to move for hours, whereas such movement is suspended in a few minutes if no chromogenic culture is added. Further proof that the evolved gas is oxygen is shown by the ability of the gas to reoxidize reduced indigo carmine. The addition of $HgCl_2$ stops the evolution, and as it occurs in darkness, it cannot be regarded as a photosyntactic product. Ewart arrives at the conclusion that the evolution is a purely physical process, the bacterial pigment having the power of absorbing oxygen, then gradually evolving it again. The oxygen is held in much the same way as it is in oxyhaemoglobin. The biological significance of this process is a question asked but unanswered.

The chlorophyllose and purple bacteria are also considered in relation to their oxygen evolving properties. Engelmann's proof for the evolution of oxygen from these green bacteria was by exposing them to cultures of some spirillum, but Ewart claims to have been able to isolate chlorophyll from cultures of these forms. He also shows that the purple bacteria likewise have photosyntactic powers, although this property is not marked. The conclusion is that the evolved oxygen in these cases is the result of photosyntactic activity.—H. L. RUSSELL.

THREE STATION bulletins of recent date having botanical interest are the following: J. C. Whitten (Mo. no. 38, pp. 140–164) shows with excellent data that the winter killing of the flower buds of peach may be greatly lessened by shading the tree with board or cloth screens, or by covering the branches with whitewash. One cuts off the direct rays of the sun, and the other reflects them. The former is especially effective, while the latter saved 80 per cent. of the buds when only 20 per cent. survived unprotected. J. F. Duggar (Ala. no. 87, pp. 459–488) gives the result of inoculating the soil for vetch, peas, clover, lupine, and other leguminous plants, with soil in which such plants had previously grown and with the imported commercial article, known as nitragin, in both pot and field culture. Results largely favored the inoculated plants. P. H. Rolfs (Fla. no. 41, pp. 517–543) announces the occurrence in Florida, and possibly in California, of an important fungous parasite of the very destructive San Jose scale insect. It is *Sphaerostilbe coccophila* Tul., native of warm countries, United States and elsewhere. It clears the tree of insects more thoroughly than any artificial means so far devised. The infection is easily disseminated from both natural and laboratory grown material.—J. C. A.

A BULLETIN (no. 9), prepared by Professor L. H. Pammel, has just been issued by the government Division of Agrostology. It deals with the grasses and forage plants of Iowa, Nebraska, and Colorado. The three divisions of the bulletin deal with the following subjects: General observations upon the physical conditions and other important questions in reference to forage in these states; a list of the more important grasses and forage plants of the region; and a list of the grasses of the three states collected by Professor Pammel during 1895 and 1896.— J. M. C.

DR. SMITH ELY JELLIFE has published in the *Journal of Pharmacology* (Nov.) a very useful paper entitled "On some laboratory molds." It deals with the more common molds and yeasts in a descriptive way, text cuts being used, and analytical keys provided. The purpose is to aid in the rapid identification of such forms as may arise in connection with the various laboratory cultures.—J. M. C.

THE INTEREST in mushrooms and mycophagy generally is not very widespread in the United States. Those acquainted with the real nutritive and gastronomic worth of fleshy fungi wonder that they do not become a standard food for both rich and poor. Every aid toward this end should be heartily welcome. The last contribution to the subject is a bulletin (no. 138) from the Cornell Experiment Station, by Geo. F. Atkinson,[25] which gives a very full account of two common mushrooms, *Agaricus campestris* and *Lepiota naucina*, and of a poisonous species, *Amanita phalloides*. The attempt has been made to give such clear, detailed and untechnical descriptions of these plants, aided by carefully prepared illustrations, that the novice may identify them with reasonable certainty, and moreover find himself attracted toward the subject. All but two of the cuts are from photographs, and more perfect illustrations in black and white could hardly be made.—J. C. A.

[25] GEO. F. ATKINSON, Studies and illustrations of mushrooms, Bull. Cornell Exper. Sta. no. 138, pp. 337–356, *figs. 27*. Ithaca, September 1897.

NEWS.

PROFESSOR W. BELAJEFF, of the University of Warsaw, has been appointed director of the botanic garden of Warsaw.

MISS ANNA ARMA SMITH has been appointed assistant in botany in Mt. Holyoke College.

DR. A. O. KIHLMAN, docent in the University of Helsingfors, has been promoted to an assistant professorship of botany.

OIL DISTILLED from birch tar is coming into increased use for imparting the characteristic odor of Russia leather to all sorts of thin leather in the manufacture of fancy articles.[1]

MR. EDWIN B. ULINE has just received the Doctor's degree from the University of Berlin, where he has been at work for two and a half years. He will return to America early in January.

ATTENTION is called to the fact that the authorized agent in Germany for the BOTANICAL GAZETTE is now the well-known publishing firm of Gebrüder Borntraeger, 46, den Schönebergerstrasse 17a, Berlin, S. W.

THE STATES of Michigan, New York, and Indiana, together with a few scattered localities, produced this year about 250,000 kilos of peppermint oil, as against less than 200,000 for 1896. About one-third the total product is sent to Germany.

THE SETS of Colorado plants prepared by Mr. C. F. Baker during 1896, and advertised in this journal, have all been sold. The specimens were well selected and preserved, and were mostly purchased by the larger institutions and added to the working herbaria.

THE NINTH SECTION of the wall charts of Professor Kny, consisting of plates 91–100, has recently been issued by Paul Parey, Berlin. These illustrate the structure and development of the glandular hairs of lupine; the pollination of *Aristolochia Clematitis;* and the development of *Aspidium Filix-mas.* To the latter, eight of the ten plates are devoted.

THE WASTE CEDAR from lead pencil factories is the chief source of the raw material for the distillation of cedar oil, which is extensively used by

[1] SCHIMMEL & Co., Semi-Annual Report, Oct. 1897, p. 7.

manufacturers of cheap soaps. The demand for the oil is increasing so that this source threatens to become inadequate, in which case the wood in blocks will have to be used. This would make the oil four to six times as costly as at present, say Schimmel & Co.[2]

IN THE *Popular Science Monthly* for September there are three matters of botanical interest: (1) an illustrated account of the giant cactus, by Professor J. W. Toumey, who is certainly most competent to deal with such a subject; (2) an interesting paper on the scope of botany, by Dr. George J. Peirce, now of Stanford University; and (3) a sketch, with portrait, of Professor Samuel Lockwood, who was one of those charming old-time "naturalists" who are fast disappearing.

THE TREATISE on diatoms which Dr. Henri van Heurck had long in preparation has just been published in England, translated by Mr. Wynne E. Baxter. It forms a handsome volume of 600 pages, illustrated by about 2000 figures. All recognized genera of the world, 192 in number, are figured and also representatives of many rejected genera. All species of the North sea and countries bordering thereon are figured and described. A French edition may be published provided enough subscriptions are obtained to promise its success.

THE MUSHROOM PLATES accompanying Mr. Charles H. Peck's report for 1894 as state botanist of New York, which excited so much interest when issued a few months ago that the edition was speedily exhausted, have been ordered by the Regents to be reprinted in an edition of 1000 copies in the form of wall charts. They can be had in sheets or mounted upon rollers. It is a pity that plates that have attracted so much attention and from which so much is expected are not less crudely executed. The coloring has only sufficient fidelity to nature to be remotely suggestive.

THE SECRETARY OF AGRICULTURE has included in his estimate of the expenditure for the coming year an item of $20,000 to be set aside from the seed fund for the introduction of valuable economic plants. In case this expenditure is sanctioned by Congress, Mr. D. G. Fairchild will be put in charge of the work. If the scheme of seed distribution ever had in it a scientific purpose, that purpose will certainly be carried out more wisely by this method suggested by the Secretary. The importance of such work no one, can doubt, and the fitness of Mr. Fairchild, who has traveled so extensively, is at once apparent.

THE BIOLOGICAL SURVEY of Alabama is being developed and extended as rapidly as limited means will permit. Over 20,000 specimens have been added to the herbarium collections during the present year, including fine

[2] *Ibid.* p. 13.

series of mosses, lichens, and hepatics. Much of the success of the work is due to the activity and devotion of Professor F. S. Earle, and Mr. Carl F. Baker of the Alabama Polytechnic Institute and botanists of the survey. It is contemplated to offer sets of exsiccatae at about $7.00 per hundred, and also to make exchanges to some extent, in order to provide additional funds and material for the herbarium.

GEBRÜDER GOTTHELFT, of Cassel, announce the early publication of a new set of wall charts in five series: 1, physiology; 2, anatomy; 3, taxonomy and phylogeny; 4, morphology; 5, diseases. Dr. F. G. Kohl, professor of botany in the University of Marburg, will prepare the original drawings or select those of other authors to be reproduced. These will be largely from photographs. A larger size than usual, 85×115^{cm} will allow the lines to be coarse enough to be seen in a large lecture hall. The price is to be reasonable, viz., *M* 5 per chart, unmounted; if mounted with rings and roller, *M* 2 additional. Single charts may be purchased, or any series. Sample plates will be sent free on request.

THE APPEARANCE of the *Plant World* justifies its announcement. Two numbers are now before us, and a statement of contents is the best sort of comment. The October number contains "The sword moss," by Mrs. E. G. Britton; "The families of flowering plants," by Charles L. Pollard, the beginning of a series of articles; "Sensitiveness of the sundew," by F. H. Knowlton; "Ferns of the Yosemite and the neighboring Sierras," by S. H. Burnham; "Some sand-barren plants," by Willard N. Clute. There is also an editorial department and one of "notes and news." The November number contains articles by F. H. Knowlton, Charles L. Pollard, A. A. Heller, Arthur Hollick, and W. J. Beal. We hope that the journal has "come to stay."

THE FOLLOWING reliable information about the cultivation of orris (*Iris florentina* L.) may be of interest, as it is of great importance to the perfumery industry and little has been known about it. The cultivation of this plant has been going on in Italy for two centuries. It is planted on hills and hillsides, never in valleys; mostly on sunny clearings or lengthwise between rows of vines in vineyards, seldom in extensive fields. It grows only in dry stony ground. Once planted, the plants need no further care and are left undisturbed for two or three years. Then the gathering of the rhizomes commences. Half the last joint is left on the living plant, which is replanted in new ground at once or within a fortnight. The freshly cut rhizomes are first placed in water to facilitate peeling, after which they are dried in the sun. 100 kilos of green rhizomes make 30–40 kilos of dried. The Tuscany districts will yield this year about 1,250,000 kilos.[3]

[3] SCHIMMEL & Co., Semi-Annual Report Oct. 1897, p. 38.

THE BAUSCH & LOMB OPTICAL CO. announce their intention to begin the publication, on January 1, of an octavo sixteen-page monthly periodical devoted exclusively to the science involving the use of the microscope, particularly in the line of practical methods of working, the description of new apparatus and the recording of new uses for already described appliances, new and useful formulæ for staining, fixing, mounting, etc., news about prominent men and institutions both domestic and foreign, correspondence and criticism and current literature. The paper and printing are to be of the best, and accurate illustrations will be provided when required.

It is proposed to conduct this journal in the most conservative manner as to the accuracy and practical value of the matter. As there is at present no publication in this country devoted to the above mentioned subjects exclusively, the company has been repeatedly urged to establish and maintain such a periodical. They hope to receive the hearty support of all interested in the advancement of science.

GENERAL INDEX.

The most important classified entries will be found under Contributors, Diseases, Hosts, Necrology, Personals, and Reviews. Names of new species are printed in **bold-face type**; synonyms in *Italics*.

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